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ABSTRACTS
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Annual Meeting

# AMERICAN CERAMIC SOCIETY

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Week of February Eleven

# THE DIELECTRIC STRENGTH OF PORCELAIN: THE INFLUENCE OF POROSITY*

By A. J. Monack and R. K. Smith

ABSTRACT

This work utilized the samples used by Monack, Shardlow, and Wamsley in previous experiments.[1] Between cones 7 and 10, the dielectric strength was found to be inversely proportional to the per cent apparent porosity. Between cones 10 and 15 the dielectric strength increased gradually while the apparent porosity remained essentially zero. No relation existed between dielectric strength and total porosity (open and closed pores). Overfiring does not seem to decrease the dielectric strength unless a definite vesicular structure is developed.

## I. Introduction

A large number of specimens of porcelain being available as the result of previous work,[1] it was decided to carry out an investigation of the influence of porosity on their dielectric strength. The specimens were prepared

Table I

Summary of Data

| Cone No. | No. of samples | Mean apparent porosity (%) | Mean kilovolts/ 1/4 inch | Mean bulk specific gravity |
|---|---|---|---|---|
| 7 | 18 | 7.90 | 37 | 2.33 |
| 8 | 20 | 3.97 | 51 | 2.41 |
| 9 | 20 | 1.62 | 60.5 | 2.43 |
| 10 | 19 | 0.28 | 63 | 2.48 |
| 11 | 20 | 0.33 | 61 | 2.48 |
| 12 | 20 | 0.24 | 64 | 2.48 |
| 13 | 21 | 0.21 | 60 | 2.43 |
| 14 | 21 | 0.24 | 69.5 | 2.34 |
| 15 | 18 | 0.33 | 67 | 2.19 |

and fired with unusual care and their dielectric strengths were measured with the use of sufficient samples to give reliable results.

## II. Experimental Procedure

The composition of the porcelain, the preparation and firing of the specimens, and the measurements of dielectric strength have been described in a previous paper by Monack and Shardlow.[2] The only new procedure was that of determining the porosity.

The specimens were dried to constant weight in a desiccator over concentrated sulfuric acid, and were weighed carefully before placing in the bomb. A vacuum was applied to obtain a residual pressure of less than one centimeter before water was introduced in sufficient quantity to cover the specimens which remained in the bomb for forty hours. After soaking, the specimens were weighed suspended in water. Following a submersion in mercury to dry them, the specimens were weighed to obtain

* Presented at the Annual Meeting, American Ceramic Society, Pittsburgh, Pa., February, 1933 (White Wares Division).

This investigation was carried out in the Department of Ceramic Engineering, of which C. W. Parmelee is the head, as part of a coöperative agreement between the Engineering Experiment Station, whose director is M. S. Ketchum, and the Utilities Research Commission, Inc., of Chicago, Illinois, of which W. L. Abbott is chairman.

[1] *Jour. Amer. Ceram. Soc.*, **15** [2], 126–29 (1932).

[2] *Ibid.*, **14** [9], 603–607 (1931).

the saturated weights. The calculations for open pores, etc., were made in the usual manner.[3]

The true specific gravity of one specimen at each cone temperature was determined by the pycnometer method to obtain knowledge of the trend of this property.

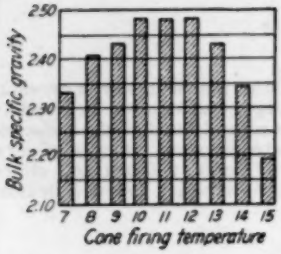


FIG. 1.—Mean bulk specific gravities of specimens fired to different cone temperatures.

## III. Discussion of Results

NOTE: For the method employed in this work, an apparent porosity of 0.30% or less was taken as zero because the accuracy of the measurements was no greater than this, and because irregularities in the surface of a specimen may easily give a supposed porosity of considerable magnitude.

Although the specimens were fired as high as cone 15, it was impossible to develop a vesicular structure. The decrease in bulk specific gravity (Fig. 1) after cone 12, however, may be considered as an indication of overfiring and the proper firing range for the porcelain used here from the viewpoint of porosity only may be taken as cones 10 to 12.

Figure 2 shows that the dielectric strength increased rapidly in the range between cones 7 and 9; above that the increase was gradual. The same figure indicates the rapid decrease in apparent porosity between cones 7 and 10, and the zero apparent porosity after that.

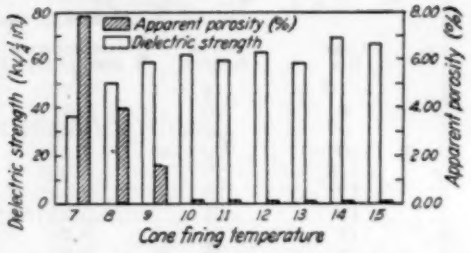


FIG. 2.—Mean dielectric strength and mean apparent porosities of specimens fired to different cone temperatures.

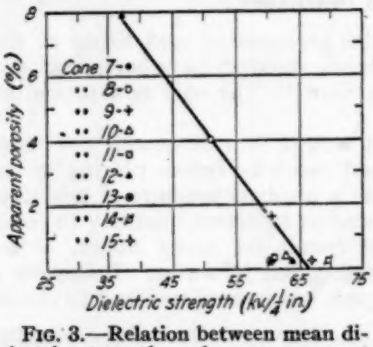


FIG. 3.—Relation between mean dielectric strength and mean apparent porosities.

From Fig. 3 it can be seen that the relation between dielectric strength and apparent porosity is an inverse linear one between cones 7 and 10. Yet, because such a plot may give an erroneous impression, Fig. 4 was drawn, plotting the individual measurements rather than the arithmetic means, so that a dot (or scatter) diagram resulted. The coefficient of correlation[4] may be calculated for this diagram, giving a result which is more reliable and more correctly expressive than the method of using arithmetic means.

Since the bulk specific gravity de-

[3] Report of Standards Committee, *Jour. Amer. Ceram. Soc.*, **11** [6], 456 (1928).

[4] See A. E. R. Westman, *ibid.*, **10** [3], 133–47 (1927); Handbook of Mathematical Statistics, H. L. Rietz, Editor-in-Chief, Houghton-Mifflin Company, New York, 1924.

creased beyond cone 12, since the true specific gravity showed a gradual decrease throughout the entire range from cones 7 to 15, and since the apparent porosity remained constant from cones 10 to 15, it is evident that the volume of closed pores must have increased beyond cone 12. Nevertheless, the dielectric strength continued to increase gradually leading to the conclusion that the closed pores have no direct influence on the dielectric strength, and that, consequently, the total porosity of the porcelain is not an important factor.

The presence of a definite vesicular structure caused by overfiring would undoubtedly decrease the dielectric strength.

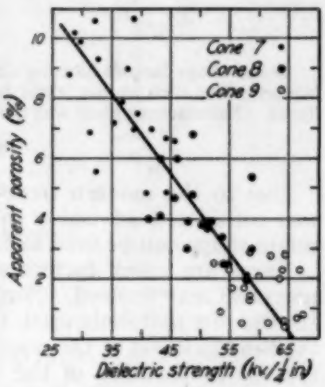


FIG. 4.—Scatter diagram showing the relation between per cent porosity and the dielectric strength in the range of cones 7 to 9.

Although this investigation shows that decided overfiring does not decrease the dielectric strength, it must be remembered that the development of brittleness with higher firing is a serious defect in porcelain, and that proper firing involves a compromise between electrical and mechanical properties in the resulting product.

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# RAPID FIRING OF SEMIPORCELAIN*

By J. T. Robson

ABSTRACT

Some of the factors limiting the firing cycle of semiporcelain ware are listed. Satisfactory seven-inch bisque, eight high, was obtained with a complete firing cycle of 15½ hours. Satisfactory glost was obtained with a complete firing cycle of 8½ hours.

## I. Introduction

Due to the modern trend of firing in small units on a rapid cycle, it was considered advisable to determine how rapidly a standard semiporcelain shape can be fired satisfactorily in both bisque and glost.

There are many factors which enter into the speed with which semiporcelain may be fired. Some of these are (1) the composition of the body, (2) the raw materials used, (3) the oxidation required, (4) the shape fired, (5) the thickness of the ware, (6) the height to which the ware is stacked, (7) the preparation of the body with regard to the elimination of air, (8) the uniformity of the application of heat around the ware, and (9) the uniformity of cooling.

In this work standard 7-inch semiporcelain plates were used. These were stacked eight high in a bung, which is the usual number stacked per bung on the boards received from the green room by the kiln placer.

The plates, one bung of eight in each test, were fired in a 12- by 12- by 24-inch one-piece muffle. The gas burner was located at the back end of the furnace below the muffle and the door of the muffle was set inside the firing chamber so that heat was applied completely around all sides of the muffle.

In addition, the bungs of plates on setters were set up on the edges of two brick so that they were 4½ inches off the muffle floor and as much as possible out of contact with the muffle and refractories, insuring a uniform heating and cooling of the ware itself.

A thermocouple was placed about ¼ inch above the center of the top plate and pyrometric cones right beside the bung. The rate of firing was recorded on a temperature recorder.

After firing, one or more of the plates as designated were broken and absorption tests run on pieces from the edge of the plate and the center to determine the uniformity of the fired ware.

**(1) Bisque Test No. 1** The heating time was 10 hours and the cooling time 11½ hours, a total of 21½ hours. The maximum temperature was 2110°F with cone 9 started.

All plates fired satisfactorily in this test except the third from the bottom, which had what appeared to be a heating-up crack although it is quite possible that this plate was strained prior to or during placing in the kiln.

The absorption of the outer rim *versus* the center is given on the following page.

**(2) Bisque Test No. 2** The heating time was 6½ hours and the cooling time 4½ hours, a total of 11 hours. The maximum temperature was 2220°F with cone 9 touching.

In this fire there was noticeable warping and the two bottom plates had foot pulling which resulted in their dunting or cracking during cooling.

* Presented at the Annual Meeting, American Ceramic Society, Pittsburgh, Pa., February, 1933 (White Wares Division). Received April 3, 1933.

| Height | | Absorption Outside rim (%) | Center (%) |
|---|---|---|---|
| Bottom | 1 | 5.2 | 4.8 |
| | 3 | 5.3 | 9.0 |
| | 5 | 6.9 | 6.9 |
| | 7 | 9.7 | 6.6 |
| | 8 | 5.4 | 6.8 |
| | Average | 6.5 | 6.8 |

The absorptions were as follows:

| Height | Absorption Outside rim (%) | Center (%) |
|---|---|---|
| Bottom | 4.20 | 5.15 |
| Top | 5.45 | 6.43 |

Since this test showed the heating time to be too rapid it was slowed down in Test No. 3.

**(3) Bisque Test No. 3** The heating time was $8^1/_2$ hours and the cooling time $5^1/_2$ hours, a total of 14 hours. The maximum temperature was 2225°F with cone 9 touching.

The three bottom plates warped slightly and the foot pulled on the bottom plate. There were no heating cracks or cooling dunts.

The absorptions were as follows:

| Height | Absorption Outside rim (%) | Center (%) |
|---|---|---|
| Bottom | 5.33 | 5.96 |
| Top | 6.60 | 7.63 |

**(4) Bisque Test No. 4** This test was a time duplicate of Test No. 3 at lower temperatures with plates from a different manufacturer to test the foot-pulling tendency in these rapid heating-up tests.

The heating time was $7^1/_4$ hours and the cooling time 6 hours, a total of $13^1/_4$ hours. The maximum temperature was 2150°F with cone 8 touching, cone 9 just started.

There was no warping, but the foot pulled on the four bottom plates resulting in dunting.

The absorption of the bottom plate was rim 7.60% and center 7.52%.

**(5) Bisque Test No. 5** This test was run using 7-inch plates from a third manufacturer.

The heating time was $7^1/_2$ hours and the cooling time 7 hours, making a total firing time of $14^1/_2$ hours. The maximum temperature was 2145°F with cone 9 started.

The bottom and fourth plates had no foot pulling, but dunted.

The absorption of the bottom plate was outside rim 7.69% and center 8.65%.

**(6) Bisque Test No. 6** This test was run, using plates from the same manufacturer as those used in Test No. 5, but with a more gradual cooling curve from 1200°F down.

The heating time was $7^1/_2$ hours and the cooling time 8 hours. The cooling time from 1200° down to 400° where the ware was removed from the kiln was $6^3/_4$ hours as against $5^3/_4$ hours in Test No. 5 and 5 hours in Test No. 4. With satisfactory cooling in Test No. 1 the time required for

cooling from 1200 to 400° was $8^3/_4$ hours. The total time for Test No. 6 was $15^1/_2$ hours. The maximum temperature was 2205°F with cone 9 started. All plates fired well with no warping, heating-up cracks, or dunting. The absorptions were as follows:

| Height | | Absorption Outside rim (%) | Center (%) |
|---|---|---|---|
| Bottom | 1 | 6.45 | 7.87 |
| | 4 | 7.20 | 9.75 |
| | 5 | 7.75 | 9.20 |
| Top | 8 | 8.52 | 8.86 |

**(7) Comments** Tests Nos. 5 and 6 indicate that this manufacturer, having a more open body, does not have the foot-pulling tendency shown in Test No. 4. Tests Nos. 2 and 3 show foot pulling on the lower plates in the bung, but the maximum temperature was too high, resulting in absorptions below 6% on the low plates in the bung.

In the cooling cycle the ware was cooled rapidly to 1200°F actual ware temperature and then slowly to 400°F, where the ware was removed.

Time did not permit a check run of Test No. 6. The results, however, show that this semiporcelain 7-inch ware, 8 high, was fired satisfactorily in the bisque in $15^1/_2$ hours.

## II. Glost Firing

In glost firing the ware is pinned so that the height to which it is set does not enter into the rate of firing as it does in bisque firing. With uniform heating and cooling, the chief problem is to mature the glaze satisfactorily over the entire surface of the flat ware.

Using three posts to hold the pinned ware, the ware in the following tests was fired in the same muffle as used for the bisque firing tests.

**(1) Glost Test No. 1** In this test five 7-inch plates and eight 5-inch plates were fired in the muffle to cone 4 down, 2030°F. The heating time was 9 and the cooling time 6, a total of 15 hours. All plates from this test were satisfactory.

**(2) Glost Test No. 2** Five 7-inch plates were fired to cone 1 half down, 2000°F. The heating time was 6 and cooling $7^1/_4$, a total of $13^1/_4$ hours. In this test all plates were satisfactory, but would have been a little brighter at a higher temperature.

**(3) Glost Test No. 3** Five 7-inch plates were fired to cone 3 touching, 2120°F. The heating time was 4 and the cooling $4^1/_2$, a total firing cycle of $8^1/_2$ hours. In this test all five plates were entirely satisfactory.

It was impossible to fire this muffle kiln to 2120°F faster than 4 hours.

## III. Conclusions

The results show that (1) 7-inch semiporcelain plates 8 high can be fired satisfactorily in $15^1/_2$ hours, $7^1/_2$ hours heating and 8 hours cooling time, and (2) 7-inch semiporcelain plates can be satisfactorily fired in the glost in $8^1/_2$ hours time, 4 hours heating and $4^1/_2$ hours cooling time.

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# POTASH–SODA–LIME FELDSPAR EUTECTIC STUDY*

By Joseph A. Maertz

ABSTRACT

An investigation was made of the fusion behavior of the potash feldspar, soda feldspar, and soda-lime feldspar system, all materials being of commercial grade. The potash feldspar had a pyrometric cone equivalent of cone $9^1/_2$, the soda feldspar, cone $6^1/_2$, and the soda-lime feldspar deformed at cone $11^1/_2$. Mixtures varying according to the triaxial diagram were made in the form of pyrometric cones. These were fired in groups along with standard Orton cones.

The 30% commercial potash feldspar-70% commercial soda feldspar mixture reached 6 o'clock deformation when standard Orton cone 6 showed 2 o'clock deformation.

The mixture of $62^1/_2$% commercial potash feldspar with $37^1/_2$% soda-lime feldspar reached 6 o'clock deformation when cone 7 showed 1 o'clock deformation, the deformation of the cone $9^1/_2$ potash feldspar being reduced 3 cones by the addition of the proper percentage of the cone $11^1/_2$ soda-lime feldspar.

There was an increase in deformation temperatures (no indication of eutectic) in the plagioclase series, soda feldspar to soda-lime feldspar.

The mixture of 30% commercial potash feldspar, 60% commercial soda feldspar, 10% soda-lime feldspar showed 6 o'clock deformation when cone 6 showed 1 o'clock deformation, this being the lowest temperature at which any member of the system showed 6 o'clock deformation.

## I. Introduction

This investigation was a study, in a limited manner, of the fusion behavior of mixtures of commercially available potash, soda, and soda-lime feldspars. The last named, although commercially available, is at present not used in ceramic manufacture.

Feldspars are solid solutions[1] and mixtures[2] of solid solutions,[3] and have variable chemical compositions. Their mineralogical[4] and other properties vary with any changes in chemical analysis.

If any given feldspar is heated to the temperature at which the formation of a liquid phase begins, the addition of heat produces a gradual increase in the proportion of liquid to unmelted solid. When sufficient time is given for the establishment of equilibrium between the various components present, for a certain temperature a definite proportion of liquid to solid results. For feldspars in general small changes in temperature make small changes in this ratio. Complex problems arise regarding the composition, the viscosity, and the amount of these melted materials, and their ability to dissolve other materials present and to form other compounds.

In general, the feldspars used for ceramic bodies are high in potash and low in soda, chosen because of their long fusion range. For glazes, the feldspars high in soda and relatively low in potash are preferred, since they produce high brilliancy, probably due to the lower viscosity of such feldspars when fused. In the high potash feldspars a limited solid solution of plagioclase feldspars is found, while in the high soda feldspars the

* Presented at the Annual Meeting, American Ceramic Society, Pittsburgh, Pa., February, 1933 (White Wares Division).

[1] (*a*) A. S. Watts, "Feldspars and Their Peculiarities as Ceramic Solvents," *Jour. Amer. Ceram. Soc.*, **13** [9], 550 (1930).

(*b*) H. L. Alling, "The Mineralography of the Feldspars," *Jour. Geol.*, April–May, 1921.

[2] A. B. Searle, The Chemistry and Physics of Clays and Other Ceramic Materials, p. 463.

[3] G. W. Tyrrell, The Principles of Petrology, pp. 65–67.

[4] Kraus and Hunt, Mineralogy, p. 354.

amount of plagioclases may reach as high as 15 to 20%. Feldspars carrying more than 2% CaO are generally looked upon with suspicion because of the high maturing temperature assigned to lime feldspar, and because of the extreme fluidity which normally develops in mixtures containing any considerable content of CaO.

While the foregoing statements indicate general practice, there are notable exceptions. One of the most famous French porcelains was found on analysis to contain almost as much soda feldspar as potash feldspar. A successful American electrical porcelain contains a mixture of two-thirds potash and one-third soda feldspar. A well-known American china contains a single feldspar of notably high soda content.

There appear to be no fundamental objections to a combination of potash and soda feldspars in vitreous bodies or to a reasonable content of lime feldspar provided the viscosity of the glass produced is sufficiently high to prevent distortion during the firing process. By adjustment of the amount of the glass-forming constituents and by proper control of the temperature during the critical stages of firing, serious losses from over-

TABLE OF CHEMICAL ANALYSES

| | Canadian potash feldspar[a] (%) | Maryland soda feldspar (%) | N. C. soda-lime feldspar (%) |
|---|---|---|---|
| $SiO_2$ | 65.36 | 68.00 | 62.56 |
| $Al_2O_3$ | 18.45 | 20.33 | 23.88 |
| $Fe_2O_3$ | 0.13 | 0.07 | 0.06 |
| CaO | 0.04 | 0.35 | 4.98 |
| MgO | 0.06 | 0.04 | 0.01 |
| $K_2O$ | 12.76 | 0.30 | 0.58 |
| $Na_2O$ | 2.43 | 10.72 | 7.95 |
| $TiO_2$ | 0.01 | | |
| $P_2O_5$ | Trace | | |
| Ignition loss | 0.28 | 0.16 | 0.23 |
| | 99.52 | 99.97 | 100.25 |
| Pulverization residue on 200-mesh screen | 0.15 | 0.17 | 0.12 |

[a] Analysis by Dana Demorest, Ohio State University.

firing should be prevented. Increase of temperature during the final stage of firing should be slow enough that progressive solution of clay and quartz could combat the tendency toward development of excessive fluidity in the glassy phase of the body.

If the amount of glass necessary for vitrification can be reduced without lowering the quality of the ware, and especially if the necessary firing temperature can be lowered two or three cones, an opportunity will be created for important improvements and economies in ceramic manufacture.

## II. The Investigation

This investigation was made with the idea that a study of the deformation temperatures of various mixtures of finely pulverized high potash, high soda, and soda-lime feldspars would reveal a low-fusing area within this three-component system.

## III. Materials and Their Preparation

The potash feldspar, Derry "dental" (microcline) from O'Brien and Fowler, Ottawa, Canada, was crushed from the rock samples by the writer.

The soda feldspar (Maryland albite) from the Consolidated Feldspar Corporation was provided as 100-mesh powder through the courtesy of F. P. Knight, Jr., The Oxford Mining & Milling Company, Inc., West Paris, Me.

The soda-lime feldspar, from Mitchell County, N. C., was provided as a 100-mesh powder by B. C. Burgess, the Tennessee Mineral Products Corp., Spruce Pine, N. C.

Chemical analyses of the albite and the soda-lime feldspar were furnished by the Oxford Mining & Milling Company laboratory.

Pulverization of all three feldspars was completed in a laboratory ball mill so that the grain size was comparable to that of commercially ground feldspars.

The norm constitutions of the three feldspars were figured according to the method of A. I. Andrews.[5]

NORM CONSTITUTIONS

| | Canadian potash feldspar (%) | | Maryland soda feldspar (%) | | N. C. soda-lime feldspar (%) | |
|---|---|---|---|---|---|---|
| Potash feldspar | 75.90 | 78.44 | 1.78 | 1.89 | 3.45 | 3.62 |
| Soda feldspar | 20.66 | 21.35 | 90.72 | 96.24 | 67.04 | 70.51 |
| Lime feldspar | 0.20 | 0.21 | 1.76 | 1.87 | 24.60 | 25.87 |
| | | 100.00 | | 100.00 | | 100.00 |
| Excess $SiO_2$ | 2.30 | | | | | |
| Excess $Al_2O_3$ | 0.46 | | 3.75 | | 3.46 | |
| $Fe_2O_3$ | 0.13 | 3.24 | 1.72 | 5.74 | 1.15 | 4.91 |
| MgO | 0.06 | other | 0.07 | other | 0.06 | other |
| $TiO_2$ | 0.01 | minerals | 0.04 | minerals | 0.01 | minerals |
| $P_2O_5$ | Trace | | | | | |
| Ignition loss | 0.28 | | 0.16 | | 0.23 | |
| | 100.00 | | 100.00 | | 100.00 | |

## IV. Procedure

Mixtures of the three feldspars were made according to the triaxial diagram, variations being by 5%, 231 mixtures in all. These mixtures were made up with a 4% solution of gum tragacanth to plastic consistency, and were formed into $1^1/_4$-inch pyrometric cones in a standard cone mold. The cones were placed on waxed paper and were dried in a gas-fired laboratory drier.

To get the comparative deformations of groups of 30 to 50 of these feldspar cones adjacent to each other in a given area on the triaxial diagram, the different cones were placed one-half inch apart in rows one inch apart in a layer of plastic refractory mixture on slabs of insulation brick. Standard Orton cones, cut down to the same size as the feldspar cones, were set at the corners midway along the four sides and in the center of a

[5] Ceramic Tests and Calculations, p. 107.

series. Each cone was set so that the trowelled face was leaning 3 to 5° from the vertical.

Tests were conducted on the different groups in a gas-fired laboratory muffle or in saggers in a gas-fired laboratory kiln, the muffle or the saggers insuring a uniform temperature throughout all parts of the cone plaques. That this was successful was indicated by the records of the standard cones distributed over the plaques. Observations were made of the progress of deformation of the cones through peepholes in the kiln door. A recording pyrometer was used to follow the temperature increase. The method of firing followed was to light the gas burners in the evening, setting them so that 400°C was reached by morning. In the next four to six hours the temperature was gradually increased to five cones below the temperature desired. In the last three to four hours the standard cone deformation desired was reached by a very gradual increase in kiln temperature.

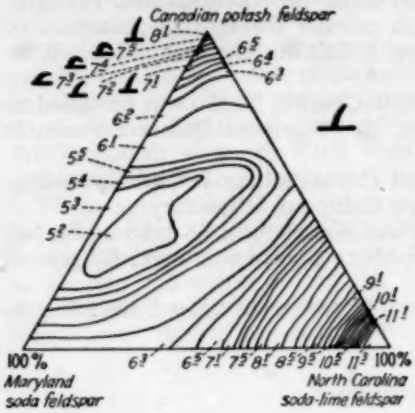


FIG. 1.—P.C.E. when the feldspar test cones showed 1 o'clock deformation.

## V. Cone Deformation Data

The data from the different tests were tabulated. Correlations were made as to areas of equal viscosity for given heat treatments, and triaxial diagrams of deformations were drawn (see Figs. 1 and 2). The amount of deformation of a given cone was considered proportional to the percentage of the liquid phase produced and inversely proportional to the viscosity. Several per cent of melted material, of course, was present before a cone showed initial deformation, and a cone was completely down when there was still a considerable percentage of crystalline phases present, as shown by examination with the petrographic microscope. The three end-member feldspars were found to deform, in comparison with standard Orton cones, as follows: Canadian potash feldspar, cone $9^1/_2$ P.C.E., Maryland soda feldspar, cone $6^1/_2$ P.C.E., and North Carolina soda-lime feldspar, cone $11^1/_2$ P.C.E. Referring to

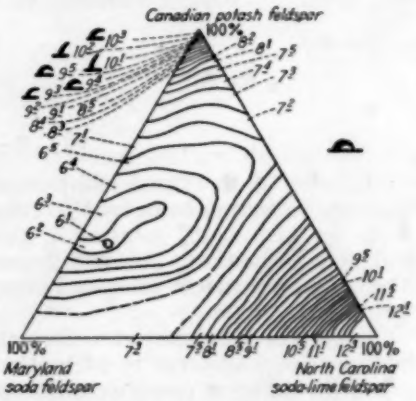


FIG. 2.—P.C.E. when the feldspar test cones showed 6 o'clock deformation.

Fig. 2, along the potash feldspar–soda-lime feldspar line, members containing 60, 62.5, and 65% potash feldspar deformed at approximately the same temperature, P.C.E. 7 (one o'clock), with the 55 and the 70% members only a little later in their deformation. The middle of this group is Canadian potash feldspar, 62.5% and North Carolina soda-lime feldspar 37.5%. This, refigured on the theoretical basis, is approximately pure potash feldspar 50%, pure soda feldspar 40%, and pure lime feldspar 10%. Evidently, the deformation of the cone $9^1/_2$ potash feldspar was reduced 3 cones by the addition of 35 to 40% of cone $11^1/_2$ soda-lime feldspar.

The mixture deforming at lowest temperature along the potash feldspar-soda feldspar line was Canadian potash feldspar 30% and Maryland soda feldspar 70%. This, refigured on the theoretical basis, is pure potash feldspar $24^1/_2$%, pure soda feldspar 74%, and pure lime feldspar $1^1/_2$%.

The 30 to 70% ratio is near the eutectic found by A. S. Watts[6] to be potash feldspar 29% and soda feldspar 69%.

The following mixture showed the earliest fusion of all: Canadian potash feldspar 30%, Maryland soda feldspar 60%, and North Carolina soda-lime feldspar 10%.

This, refigured on the theoretical basis, is approximately pure potash feldspar 25%, pure soda feldspar 70%, and pure lime feldspar 5%. This mixture started to deform at cone 5 at 2 o'clock, and went to 6 o'clock deformation when standard cone 6 showed 1 o'clock deformation.

## VI. Interpretation on Deformation Rate Data

Figure 1 shows that around the eutectic mixture there is a considerable area in which other mixtures show initial deformation at about as low a temperature as does the lowest fusing mixture. Comparing Figs. 1 and 2, the members on the margin of this area of initial deformation are distinctly more gradual in their progress to the state of fusion, as would be expected, due to their excess of material not of eutectic composition. This would tend to establish more definitely the location of the eutectic composition. A comparison of the areas of initial deformation and final deformation indicates in general that, except for the two-component eutectics on the margins of the system studied, the rate of deformation decreases toward the end members of the system. This is most pronounced toward the 100% potash feldspar corner. The difference is much less marked toward the soda feldspar and the soda-lime feldspar corners of the system.

The data suggest that the amount of feldspar employed in ceramic ware may be relatively high if the composition of the feldspar falls within the area bounded by the following members:

| | | | |
|---|---|---|---|
| Canadian potash feldspar | 100% | 65% | 75% |
| Md. soda feldspar | 0 | 35 | 0 |
| N. C. soda-lime feldspar | 0 | 0 | 25 |

Members of the system outside of this area show little promise as to gradual deformation which would contribute toward a long vitrification range in the bodies in which they are used. Outside of the area mentioned, a rather abrupt fusion of the feldspar mixture will undoubtedly occur, and the percentage of feldspar employed will have to be carefully limited in

[6] "Feldspar and Feldspar-Quartz Mixtures," *Trans. Amer. Ceram. Soc.*, **15**, 154 (1913).

order to avoid distortion of the ware due to the development of an excess of fluid glassy phase.

## VII. Limits of the Investigation

This investigation does not attempt to show the effect of the presence of kaolin, ball clay, or quartz upon the viscosity of the feldspar mixtures. No definite statement can be made as to the adaptability of any particular member or group of feldspar mixtures as vitrifying agents for ceramic bodies until a study of the effect of the other body constituents has been completed.

**Acknowledgment** Acknowledgment is due A. S. Watts, Department of Ceramics, Ohio State University, who supervised this investigation, arranged for the supplying of the feldspars used, and made many helpful suggestions.

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# SOME SHEET-IRON GROUND-COAT REBOIL AND BOND STUDIES USING SEVERAL ENAMELING STOCKS*

By H. E. Ebright, C. D. Clawson, and J. T. Irwin

ABSTRACT

This paper presents results and observations obtained from a study of metals and some metallic oxides as mill additions to eliminate or reduce reboiling of ground-coat enamels.

## Part I. Reboiling

### (A) Introduction

During the course of development work on such variables as experimental and commercial ground coats, enameling stocks, metal and metallic oxide mill additions, firing time, and temperatures, the writers have made observations on ground-coat adherence and reboiling as affected by these variables. Some of this experimental work as well as observations based on the results obtained are reported here.

### (B) Experimental

The results obtained on four enameling sheet-iron stocks were used. For convenience these stocks were called *W*, *X*, *Y*, and *Z*. Twenty-gage metal and 4- by 5-inch and 9- by 9-inch test sheets were used in the reboiling studies.

Large stock sheets of each type of enameling stock were selected from commercial shipments, care being taken to select sheets from the same heat where several sheets of the individual stocks were required. These sheets were trimmed on all four sides and, as a result, about three to four inches were "cropped" from the outside edges. This was done because in the past it was noticed that in some cases there was a 2- or 3-inch strip along one side of large stock sheets which showed serious reboiling.

The metal was cleaned in a commercial alkali metal cleaner and pickled and neutralized under closely controlled commercial conditions. For the reboil studies the test pieces were given a 5-minute pickle in an 8% sulfuric acid bath at 150°F in some cases and a 30-minute pickle in others.

Four commercial ground-coat enamels were used containing 7% dry, powdered Vallendar clay and $^3/_4$% borax as mill additions. Extra mill additions used are given on the following page.

All ground coats were milled to a fineness of 7 to 9 grams dry residue on a 200-mesh sieve, using a 50-cubic centimeter sample of the slip which had been adjusted to a specific gravity of 1.67. These ground coats were applied at a dry weight of 38 grams per square foot (total, both sides) in all cases. The firing temperature was 1580°F and the time $4^1/_2$ minutes.

Preliminary tests had shown that refiring 4- by 5-inch test pieces in a laboratory electric muffle held at 1500°F developed the reboiling (if present) in 30 seconds, while 45 seconds were required to develop the same condition on 9- by 9-inch test sheets in a large electric box-type furnace held at the same temperature. The test pieces were placed on hot pins in all cases. The 30-second refiring of the small pieces, and the 45-second refiring of the larger pieces was therefore used in the reboil studies.

Several test sheets from all four stocks were sandblasted and then

* Presented at the Annual Meeting, American Ceramic Society, Pittsburgh, Pa., February, 1933 (Enamel Division). Received March 6, 1933.

enameled with each of the four control enamels. These sheets were tested for reboiling.

### (C) Results of Reboil Studies

**(1) Enameling Stock, Pickling, and Reboiling** Test sheets from the four stocks were given a 5-minute pickle, ground-coated with the four commercial control enamels, and tested for reboiling. Stock *W* showed very slight reboiling, stocks *X* and *Y* slightly more reboiling, and stock *Z* did not reboil.

Another set of test sheets was given a 30-minute pickle and ground-coated with the four commercial control enamels. Serious reboiling occurred on stocks *W*, *X*, and *Y*, while no such condition could be observed on stock *Z*. Samples of this last stock, *Z*, in the ground coat, were refired for longer periods up to one and one-half minutes, and did not reboil. This stock received some special treatment at the mill where it

TABLE I

| Mill No. | Ground-coat frits | Extra mill addition (%) |
|---|---|---|
| A | 1 | 1 red iron oxide |
| B | 1 | 3 " " " |
| C | 1 | 5 " " " |
| D | 1 | 1 black iron oxide |
| E | 1 | 3 " " " |
| F | 1 | 5 " " " |
| G | 2 | 1 red-iron oxide |
| H | 2 | 3 " " " |
| I | 2 | 5 " " " |
| J | 1 | 1/2 metallic powdered aluminum |
| K | 1 | Standard for control |
| L | 2 | " " " |
| M | 3 | " " " |
| N | 4 | " " " |
| O | 1 | 1 metallic aluminum |

was produced, which seemed to eliminate reboiling under the test conditions described.

**(2) Sandblasting and Reboiling** Sandblasted sheets from all four stocks were ground-coated with control milling *K* and were tested for reboil. Stocks *X* and *Y* showed bad reboiling, stock *W* showed slight reboiling, while stock *Z* did not show this condition.

**(3) Metallic Oxide Additions and Reboiling** Test sheets from enameling stock *W* (which showed serious reboiling with all four control enamels) were ground-coated with enamels to which had been added various amounts of red and black iron oxide. Controls using control enamel millings *K* and *L* were prepared at the same time.

On refiring, reboiling occurred on all test sheets, although those prepared with 5% red iron oxide in ground coat No. 1 and with 3% red iron oxide in ground coat No. 2 showed a decided decrease in the amount of reboiling.

Ground-coat frits 1, 2, 3, and 4 were fused separately in platinum crucibles until quiet. While still in a quiet state of fusion, pre-ignited red iron oxide was added to the melt. The red iron oxide went into solu-

tion with each frit quietly with no evolution of gas or any indication of a vigorous reaction. This was repeated using black iron oxide. In every case an evolution of gas and some reaction seemed to be taking place.

**(4) Metallic Aluminum and Reboiling** Samples prepared from mills *J* and *O*, using enameling stock *W*, were also refired. With ½% metallic aluminum as a mill addition, slight reboiling occurred. With 1%, no reboiling could be observed. Fired test sheets prepared from mill *O* showed no tendency to reboil when refired after six months storage.

**(5) Metallic Aluminum and the Effect on Normal Bubble Structure** Normal ground coats, when examined under the microscope, were found to contain a large number of fine bubbles throughout the enamel. As can be seen in Fig. 1, there are few bubbles present in ground coat No. 1 containing ½% aluminum, and the bubbles are entirely absent from ground coat No. 1 containing 1% aluminum. This effect of metallic aluminum has been checked using other enamels and other enameling stocks.

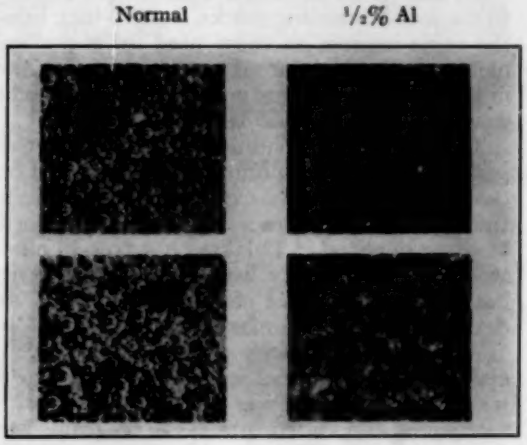

FIG. 1.

## (D) Discussion of Results of Reboil Studies

**(1) Enameling Stock** From the results obtained, it seems that the reboiling can be eliminated or reduced by special processing of the base metal at the steel mill.

**(2) Pickling** The fact that a short pickling time reduced reboiling on a stock that reboiled when pickled for thirty minutes seemed to substantiate the theory that the adsorption of gases by the metal during the pickling operation was one of the causes of reboiling.

**(3) Sandblasting** The reboiling of stocks *W*, *X*, and *Y* might indicate that gases originally present in the metal were one cause of reboiling.

**(4) Metallic Oxides** The fact that 5% red iron oxide in ground coat No. 1 and 3% in ground coat No. 2 resulted in a decided decrease of reboiling is interesting. It is difficult to explain the reasons for this reduction of the reboiling tendency but numerous rechecks have borne out these results.

**(5) Metallic Aluminum** The metallic aluminum was added to provide a reagent in the enamel which would react with any gases released from the base metal or from enamel-metal reactions to form solid reaction products. There would be no adsorbed gas available for release in the refire to cause reboiling.

**(6) Reboiling and Adherence** The enamel-metal bond developed on stock *Z* with all four control enamels was observed to be as good as that developed on the other three stocks.

In every case where reboiling was reduced or eliminated by means of mill additions in the ground-coat enamel, a serious decrease in adherence of enamel to the base metal was noticed.

## Part II. Bond or Adherence

The next step in this experimental work was to study the relationship which might exist between reboiling and adherence of the ground coat to the metal.

### (A) Experimental

To determine the relative adherence of the various ground-coat enamels to the four enameling stocks, 9- by 9-inch samples were prepared in exactly the same manner as those used for the reboiling studies except that the pickling procedure for all test plates was limited to a period of five minutes in the acid. The same enamels were applied under the same conditions of weight, firing time, and temperature.

The purpose of confining the pickling procedure to five minutes in the acid solution was to eliminate any increased bonding effect from etched surfaces. From previous experiments it was indicated that increased pickling time produced a surface which in the majority of cases showed improved bonding qualities. This was not true in all cases, however, for enameling stock *W* showed very little improvement with thirty minutes in the acid bath, while enameling stocks *X*, *Y*, and *Z* showed decidedly better bond development with similar treatment.

After the pieces were ground-coated, two coats of a standard commercial cover-coat enamel were applied on one side only. The average dry weight of the two cover coats was held within commercial limits for all test pieces and varied from 63 to 65 grams per square foot total dry weight for both coats. The firing temperature was held at 1500°F and the time used was $2^1/_2$ minutes for each firing of the cover-coat enamel.

These sheets were subjected to the impact of a 1175-gram free-falling weight with a spherical tip one-half inch in radius. The weight was allowed to fall from a height of 75 centimeters striking the cover-coated side of the test plate. The sample being tested was clamped in place and was supported by a metal base having a circular opening $1^1/_{16}$ inch in diameter directly under the point of impact. The degree of adherence was determined by the appearance of the break. A study of the different types of breaks shown in Fig. 3 will show their different appearances due to various degrees of bond.

### (B) Results of Bond Studies

Under all conditions of firing with different enamels and different mill additions, the enameling stocks *X*, *Y*, and *Z* showed similar bond development. Enameling stock *W*, however, showed decidedly less bond development in every case.

**(1) Normal Bond Development** Figure 2 is a photomicrograph of the junction line of a metal and enamel which showed good bond from impact tests. This cross-section was taken from a

test plate made from enameling stock *X* and coated with ground-coat frit No. 1. This plate was fired in ground coat for $4^1/_2$ minutes at 1580°F. The results of impact tests on this same sample may be observed by examining the break shown on Fig. 3 in the upper left corner. Since both the enamel and enameling stock were known to be commercially satisfactory and as standard enameling practice was used, it is reasonable to assume this bond to be both normal and satisfactory.

FIG. 2.

**(2) Effect of Increased Firing Time** Both firing time and temperature are important factors in bond development. From previous and more detailed studies, the time factor appears to be the more important. The influence of time on adherence may be noted by an inspection of Fig. 3. This is evident particularly in the case of ground-coat frit No. 1. The bond is shown to increase from "poor" to "normal" with an increase of firing time.

**(3) Effect of Ground-Coat Composition** Figure 3 shows four different ground-coat frits, Nos. 1, 2, 3, and 4, applied on enamel stock *X*. A study of the figure shows a vast difference in the bonding effect of enamels of different composition. Outstanding in bond development is ground-coat frit No. 3. The ground-coat frits in order of their adherence qualities are Nos. 3, 4, 1, and 2.

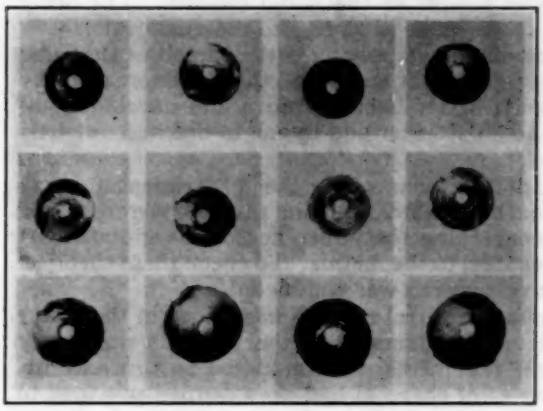

FIG. 3.

The exact explanation of the effect of enamel composition is still obscure and will require further study. It is known, however, that those enamels showing the best bond development have the greatest affinity or capacity for dissolving iron oxide.

Enameling stock *W*, treated in the same way, indicated a general decrease in the amount of bond on all test pieces.

Similar tests showed that enameling stock *X* developed, under identical conditions, decidedly better adherence than stock *W*.

Additions of black iron oxide to ground-coat frit No. 1 applied on enameling stocks *X* and *W* had a harmful effect on bond development.

The effect of red iron oxide was very much the same as that obtained with black iron oxide in regard to bond development.

There was one outstanding difference noted where red iron oxide was

added to the mill. Every test plate coated with any of the ground-coat enamels containing this material developed process fishscale at the shorter firing time of $2^1/_2$ minutes regardless of the enameling stock used. Furthermore, all enamels containing 5% of red iron oxide showed process fishscale regardless of firing time or enameling stock used. Although this is true, additions of red iron oxide did reduce the reboiling tendency. This fishscaling tendency was not noted with any of the other metal or metallic oxide additions nor with the standard control enamels.

Copperheading tendencies also became evident with increasing amounts of red iron oxide. When additions of 5% were reached the fusing temperature of the enamel was considerably lowered and the copperheading condition became serious.

Another interesting comparison to make at this point is that enamel showing the greatest copperheading tendencies with the addition of increasing amounts of red iron oxide were those having the lowest rate of iron oxide absorption.

Impact tests were made on enamels containing metallic aluminum. The results showed a decided lessening of bond with increasing amounts of this material. The white cover coat also showed a serious black speck condition.

**(4) Effect of Fine and Coarse Grinding** In conducting this experiment, commercial ground-coat enamels of identical composition were used. One of the enamels was ground so that a dry residue of 5 grams remained on a 200-mesh sieve after washing through a 50-cubic centimeter sample of the liquid enamel. The other was ground to a dry residue of 12 grams according to the same test.

A bonding range study was made by applying both enamels at the same weight on the same enameling stock. It was found that the more coarsely ground enamel showed a much better bonding range and developed adherence at temperatures 20 to 30°F lower and in one to one and one-half minutes less time.

**(5) Effect of Insufficient Oxygen in the Furnace Atmosphere** In the course of the experimental work outlined above certain theories were evolved concerning the adherence of the ground-coat enamel to the metal. To check these theories, the following elementary investigation was conducted.

For this specific study the same control enamels mentioned in this paper were prepared and applied in accordance with the methods previously outlined. The firing of these test pieces was conducted in a furnace atmosphere in which a few pieces of charcoal had been burned previous to the firing of the samples. The furnace atmosphere conditions developed by this procedure absolutely prohibited the development of any good bond regardless of the kind of enamel or enameling stock. This seemed to lead to the conclusion that the presence of a sufficient supply of oxygen was vital to the development of adherence since the furnace atmosphere was known to contain considerably less than the normal amount of this element.

A recheck was made by burning iron sulfide in the furnace before the firing of the test pieces. The results in this case were identical, thereby further advancing the theory that an insufficient amount of oxygen in the furnace atmosphere seriously retarded the development of adherence between the ground coat and the base metal.

## (C) Summary

From the above experimental information certain facts concerning the development of the bond between the ground-coat enamel and the base metal appear evident.

(1) A sufficient supply of oxygen in the furnace atmosphere was necessary for adherence.

(2) The degree of bond was decidedly affected by the type of surface presented by various enameling stocks. Therefore, the pickling time was an influencing factor.

(3) The degree of bond was also greatly influenced by enamel composition.

(4) The degree of bond was greatly affected both by firing time and temperature. From previous experiments not described in this paper the time factor appeared to be the more important.

(5) Finely ground enamels retarded the development of bond.

(6) The addition of red iron oxide, black iron oxide, and metallic aluminum retarded bond development.

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# RESULTS OF SOME SHOP TESTS ON REBOILING*

By Frank R. Porter

ABSTRACT

The reboiling problem was studied in the plant from three viewpoints, as follows: (1) *ground coat*, type of milling conditions and application; (2) *processes*, metal cleaning and ground-coat drying and firing; and (3) *enameling iron*, source and gage.

## I. Introduction

Some time ago an enamel shop had a serious epidemic of copperheading, black specks, and reboiling. The copperheading appeared spasmodically in the ground coat and was so severe that the ware was unfit for finishing. Black specks also appeared spasmodically in finish coats, particularly on those parts receiving a decalcomania transfer. Reboiling, too, was more pronounced in the finish on those parts receiving a decal fire.

The usual procedure of making certain that cleaning the ware, ground-coat dipping, and firing were being carried out as specified did not correct the trouble. It was necessary then to extend the investigations in an effort to find the cause of the trouble so that when the causes were found they could be eliminated either by making required changes in the shop processes or, if necessary, by eliminating faulty material.

## II. Investigation

The investigations were extended in the following directions: (1) ground coat, (*a*) type, (*b*) milling conditions, and (*c*) weight of application; (2) processes, (*a*) metal cleaning, (*b*) ground-coat drying, and (*c*) ground-coat firing; and (3) enameling iron, (*a*) source and (*b*) gage.

## III. Ground Coat

**(1) Type** The type of ground coat used was one in which the "hardness" could be varied by varying the percentages of "hard" and "soft" frit used, the two-frit type. Frits from several sources were used. The enamels were all milled to 6 to 7 grams dry residue on a 200-mesh sieve using a 100-gram sample of the slip. The mill additions are given at the top of the following page.

The slips were used on similar shapes which were made from a lot of enameling steel that had given trouble. The enameling processes, cleaning, ground coating, and firing were also similar.

The results showed that none of the ground coats overcame the trouble.

**(2) Milling Conditions** For this experiment a standard ground coat was used. The clay was varied from 6 to 7 1/2 by 1/2 pound per 100 pounds of frit addition; the borax was varied from 1/2 to 1 by 1/4 pound; the fineness of milling was varied from 4 to 9 grams dry residue on 200-mesh sieve. Only one change was made at a time. None of these changes improved conditions.

**(3) Weight of Application** Weight of application varied from 1 1/4 to 2 ounces per square foot (two sides). Increase of the weight of application in general tended to overcome the trouble but

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* Presented at the Annual Meeting, American Ceramic Society, Pittsburgh, Pa., February, 1933 (Enamel Division).

| Frit (lb.) | Clay (lb.) | Borax (lb.) | Feldspar (lb.) | Bentonite (oz.) | Magnesium carbonate (lb.) | Water (lb.) |
|---|---|---|---|---|---|---|
| Standard formula | | | | | | |
| A (hard) 70<br>B (soft) 30 | 6¾ | 1 | 3 | 2 | 0 | 60 |
| A (hard) 60<br>B (soft) 40 | 6¾ | 1 | 3 | 2 | 0 | 60 |
| A (hard) 80<br>B (soft) 20 | 6¾ | 1 | 3 | 2 | 0 | 60 |
| C (hard) 70<br>D (soft) 30 | 7½ | ½ | 0 | 2 | 0 | 60 |
| C (hard) 70<br>E (soft) 30 | 7 | 1.0 | 0 | 2 | 0 | 60 |
| C (hard) 70<br>F (soft) 30 | 7 | 1.0 | 0 | 2 | 0 | 60 |
| G (hard) 80<br>H (soft) 20 | 7 | ¼ | 3.0 | 0 | ¼ | 40 |
| I (hard) 70<br>J (soft) 30 | 7 | ⅛ | 0 | 0 | 0 | 60 |

did not, however, entirely correct the condition. This method, even if successful, would be open to the objection that increase of enamel thickness also increases the tendency to chip.

## IV. Processes

**(1) Method of Cleaning** The standard cleaning process is as follows:

(*a*) *Boil* alkaline cleaner, 8 ounces per gallon, 20 minutes.
(*b*) *Rinse*, cold running water, 2 minutes.
(*c*) *Acid pickle*, 6½ to 7½ sulfuric acid by weight, 160 to 170°, 2 minutes.
(*d*) *Rinse*, cold running water, 2 minutes.
(*e*) *Neutralizer*, 190 to 200°F, 2 minutes, made up of soda ash to strength of 0.45 to 0.55%.
(*f*) *Neutralizer* as in (*e*), but from 0.2 to 0.3%.
(*g*) *Dry*.

The cleaners of various manufacturers were tried at concentrations of from 2 to 10 ounces per gallon and warm water rinses were used. The acid pickle was varied from 4 to 10% acid and from 140 to 180°F. The time also was varied from 10 to 90 minutes.

Various neutralizers at various temperatures were tested.

None of the tests or changes produced enlightening results except the pickling tests. It was found that the more drastic the pickle the more nearly free from defects were the finished parts. For example, a 90-minute pickle in 7% sulfuric acid at 160°F was found practically to eliminate copperheading and also to reduce black specks and reboiling to a great extent.

**(2) Ground-Coat Drying** It was thought that the rate of drying the dipped ware might be such as to allow undue corrosion which was causing the trouble. The ground-coat equipment consisted of the usual dip tank containing approximately 60 gallons of slip, a continuous chain conveying the dipped ware from the operator and through the drying oven, and a drying oven (hot air) 40 feet long, open at either end, slightly elevated to conserve heat, and operating at 325° at the hot zone.

The temperatures were varied from 200 to 400°F and the chain speed from 10 to 20 feet per minute. None of these changes produced results that were successful in eliminating the defects.

**(3) Ground-Coat Firing** A continuous electric U-shaped furnace was used for firing the ground-coat ware which was conveyed through the furnace by means of suitable racks attached to a continuous chain. The preheat zone was 68 feet long and the firing zone 32 feet, 14 feet on each side and 4 feet across the end. Heating units were on the bottom of the firing chamber and on the side walls with the exception of the end where there were no side-wall units. The capacity of the units on the inlet walls was 280 kilowatts, on the outlet walls, 206, and on the floor, 57. Three Leeds and Northrup instruments provided automatic temperature control.

The usual firing conditions were a temperature of 1580 to 1600°F and a chain speed of $5^1/_2$ to 6 feet per minute. These conditions were varied from 4 to 8 feet per minute and from 1540 to 1640°F. None of the changes noticeably corrected the defects.

It was thought that better results might be obtained if the ware were fired nearer the top of the furnace rather than at the center bottom.

It was also thought that excessive radiation from the "hot" units might be causing the trouble. It was reasoned that to maintain a furnace temperature of 1580 to 1600°F the units, being "on" nearly continuously for efficient furnace loading, were actually hotter than this approximately by 200°F. Tests were made by shielding some of the ware from the direct radiation and exposing some to it. There was no noticeable difference in the results.

## V. Enameling Iron

**(1) Source** Enameling iron from six manufacturers was processed into ware and enameled under identical conditions.

It was found that iron from three sources showed defects while the other three were practically free from defects. A typical run, for example, showed 8% rejections for the "satisfactory" iron and 38% for the "unsatisfactory" iron. The parts were mixed and processed together. They consisted of oven-door panels made from 16-gage material. Inspection standards are somewhat high on this part due to its position when assembled on the range.

**(2) Gage** Iron of 16-, 18-, 20-, and 22-gage was used for experiment. In general, the results showed that 22-gage iron copperheaded as readily as 16-gage. The heavier gage iron tended to reboil more than the lighter gages when firing transfers, due probably to firing conditions and not to faulty iron.

## VI. Conclusions

The results of these shop tests demonstrated that faulty iron was the main cause of the defects, and that to a large extent the remedy was to use more drastic pickling. Trouble of this sort is not always the fault of the iron for the enamels or the shop processes may also be at fault.

Tests were made on deënameled ware which had copperheaded. Defects were also found on this ware when finished. Generally, copperheads appeared again. In some cases, there was reboiling but no copperheading. Copper spots appeared as deep etches on the deënameled sheets.

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# EFFECT OF SODIUM ALUMINATE ON CONSISTENCY AND ACID RESISTANCE OF SOME ACID-RESISTANT ENAMELS*

By G. H. McIntyre,[1] J. T. Irwin,[1] W. K. Carter,[2] and R. M. King[3]

ABSTRACT

This paper includes consistency studies and shows variations in acid resistance occurring with concentration and the method of using sodium aluminate as a setting-up agent.

## I. Introduction

It is generally recognized that the control of acid-resisting enamel slips presents some peculiar problems not encountered with nonacid-resisting types, and that a satisfactory method of control has not yet been devised that will provide proper slip consistency without producing, in some degree, either an application defect or an alteration of the normally desired physical properties. More specifically, these difficulties ordinarily encountered are as follows:

(1) The necessity of repeated additions of the setting-up agent, due to the rapid change upon aging of the yield and mobility values of the slips.

(2) Difficulty in handling certain setting-up agents due to their objectionable nature.

(3) A decrease in acid resistance, resulting either from the setting-up agent or improper manipulation.

(4) A decrease in the gloss of the fired product resulting directly from the effect of the setting-up agent.

The more commonly used agents in commercial practice have been sulfuric acid, some of the various alums, notably potassium and ammonium alum, and barium and calcium chloride. The use of alum or any chemical containing the sulfate radical tends to affect the gloss on the fired ware. Also, while the relative stability as to yield and mobility values is greatly increased by the use of alums as compared with the stability produced by sulfuric acid, the degree of stability which it is possible to obtain with such agents leaves much to be desired. Chlorides as a class tend to produce small dimples or pits in the fired surface. Experimentation, both laboratory and commercial, using sodium aluminate as the agent for producing the desired consistencies has shown that this compound offers favorable possibilities both as to the control and stabilization of yield and mobility values, as well as elimination of the ultimate defects produced by the commonly used agents. It is the purpose of this paper to give briefly the procedure of experimentation and typical data which have been obtained in connection with this problem.

(1) Comparative initial consistencies obtained by the use of various setting-up agents.

(2) Change of consistency produced through various aging periods.

(3) Variation in fired properties produced by the various setting-up agents.

(4) Consistency and fired property variation resulting from different methods of addition when using sodium aluminate as the setting-up agent.

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* Presented at the Annual Meeting, American Ceramic Society, Pittsburgh, Pa., February, 1933 (Enamel Division).

[1] Ferro Laboratories, Cleveland, Ohio.

[2] National Aluminate Corporation, Chicago, Ill.

[3] Dept. of Ceramic Engineering, O. S. U., Columbus, Ohio.

## II. Procedure

The consistency determinations reported were made by means of a Gardner mobilometer[4] which affords a means of recording in numerical terms the relative yield and mobility values for slips. These values are not absolute, but afford relative comparison.

The enamels, after milling and consistency determination, were applied and fired at 1500°F. Different specimens were fired for 3-minute and 4-minute periods.

The fired plates were given a 15-minute application of a 10% citric acid solution and coated immediately afterward with a water-alcohol malachite

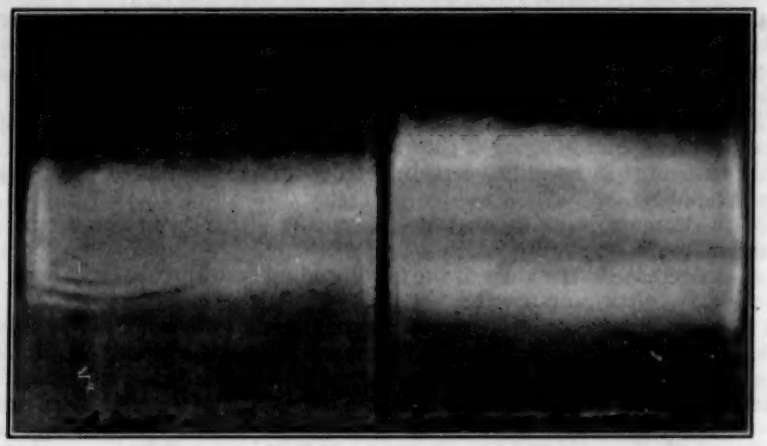

FIG. 1.—Comparison of gloss obtained with ammonium alum or sodium aluminate.

green solution. This resulted in the staining of any plates which had been attacked by the acid. The results of this test are reported as "clear" if no malachite stain is apparent, "stained" if a discoloration is noted, and "etched" if a lead-pencil mark on the stained portion can not be easily removed by rubbing with the finger. There was a considerable difference to be noted in the intensity of the various portions marked as "stained," but no distinction in the charts reporting this test has been attempted.

## III. Acid-Resisting Enamels

**(1) Consistency** From the mobilometer curves obtained it was readily noted that slips set up with sodium aluminate retained approximately the same mobility and yield values over different aging periods, while those set up with alum and sulfuric acid showed a great decrease in yield value over the same periods. This consistency stabilization is an effect which was apparent in all acid-resisting enamel slips.

[4] G. H. McIntyre and J. T. Irwin, "Application of the Gardner Mobilometer to Enamel-Slip Consistency Studies and Controls," *Jour. Amer. Ceram. Soc.*, 15 [8], 433 (1932).

**(2) Variation in Fired Properties** As stated previously, the action of certain setting-up agents is to reduce the normal gloss of the fired product. It was found that in all slips in which alum or sulfuric acid was used as the setting-up agent, the resulting fired ware plainly showed a decrease in the gloss, a scum being produced on the surface similar to that which would result from a sulfur-dioxide furnace atmosphere. The use of sodium aluminate as a setting-up agent resulted in a surface entirely free from this blemish.

It was found, however, that the use of sodium aluminate, unless it was properly controlled, resulted in a decrease in acid resistance. This was also true to a degree of other setting-up agents. In order to determine the proper manipulation of sodium aluminate, the methods of addition and firing-time variations were carried out as shown in Tables I, II, and III.

TABLE I

EFFECT OF DIFFERENT METHODS OF ADDING SODIUM ALUMINATE UPON ACID RESISTANCE

| Method of addition | Acid resistance Enamel A 1500-gram milling | |
|---|---|---|
| | 3-minute fire | 4-minute fire |
| Dry at start of milling | Stain | Clear |
| Mixed with all the mill water and added at once | " | " |
| Mixed with all the mill water and allowed to stand 1 hr. before addition (distilled $H_2O$) | Clear | " |
| Same as above except Columbus city water used | " | " |
| Mixed with all the mill water and allowed to stand 2 hr. before addition | " | " |
| Mixed with $^1/_8$ mill water and allowed to stand 2 hr. before addition | Stain | " |
| Mixed with $^1/_8$ mill water and allowed to stand 2 hr. before addition | " | " |
| Mixed with $^1/_{12}$ mill water and allowed to stand 2 hr. before addition | Etched | " |

These experiments, as will be noted, were duplicated in large and small mills and also by different operators under different conditions. They show clearly the procedures giving the best results.

## IV. Ground-Coat Enamels

Considerable laboratory experimentation has been carried out in connection with sodium aluminate in ground-coat enamel slips. These tests have not progressed to the point where a recommendation can be safely made for commercial application, and therefore, a detailed report of results is not given at this time. A brief statement is presented of these indications to date.

(1) There appeared to be a compensating change in yield and mobility values over very long aging periods. This resulted in a stability and uniformity of application properties and dipping weights.

(2) No undesirable effects resulted from the use of sodium aluminate.

## V. Nonacid-Resisting Cover-Coat Enamels

Although few laboratory data are available in connection with the use of sodium aluminate in this type of enamel, it has been used successfully in

commercial practice by operators who were also using sodium aluminate in acid-resisting enamels. The advantage of increased stability is reported to apply in these cases.

## VI. Recommendations

In obtaining the data given in this report, sodium aluminates of various grades and purity were used, and while they all produced to a degree the effects which are noted, the C.P. grade containing 92% sodium aluminate was found to give by far the best result. The amounts required in common commercial practice were from 4 to 6 ounces per 100 pounds of frit. This grade can be obtained at a cost which makes its use commercially practicable.

TABLE II

EFFECT ON ACID RESISTANCE OF DIFFERENT METHODS OF ADDING SODIUM ALUMINATE
(Sodium aluminate addition 0.25%)

| | Acid resistance Enamel B 50-lb. milling | |
|---|---|---|
| Method of addition | 3-minute fire | 4-minute fire |
| Dry at start of milling | Stain | Stain |
| Dry after 1/2 normal milling time | " | " |
| Mixed with 1/2 mill water; allowed to stand 1 hr. before addition | " | Clear |
| Mixed with all the mill water; added at once | " | " |
| Mixed with 1/4 mill water; allowed to stand 1/2 hr. before addition | " | " |
| Same as above but allowed to stand 1 hr. before addition to mill | " | " |
| Same as above but allowed to stand 2 hr. before addition to mill | " | " |

TABLE III

EFFECT OF DIFFERENT METHODS OF ADDING SODIUM ALUMINATE UPON ACID RESISTANCE

| | Acid resistance Enamel B 1500-gram milling | | | |
|---|---|---|---|---|
| | 3-minute fire | | 4-minute fire | |
| Method of addition | Lab. No. 1 | Lab. No. 2 | Lab. No. 1 | Lab. No. 2 |
| Dry at start of milling | Stain | Stain | Stain | Stain |
| Dry after 1/2 normal milling time | Etched | " | Etched | " |
| Mixed with all the mill water and allowed to stand 1 hr. before addition | Clear | " | Clear | Clear |
| Mixed with all the mill water and added at once | Stain | Clear | " | " |

## VII. Conclusions

The use of sodium aluminate as a setting-up agent in acid-resisting enamels resulted in (*a*) the production of slips more stable as to mobility and yield value than could be obtained by the use of alum or sulfuric acid; hence, slips were more easily controlled; (*b*) no decrease in the normal gloss of the fired ware; and (*c*) from these experimental laboratory data it was observed that there was no decrease in acid resistance of the fired ware as long as proper methods of addition were used. Commercial use has not fully substantiated this fact because there have been instances where even under the best methods of its use a slight decrease in acid resistance has occurred. These variations were no doubt due to variation in degree of hydrolysis of the sodium aluminate.

# EFFECT OF ZINC OXIDE ON SHEET-IRON COVER-ENAMEL PROPERTIES*

By L. D. Fetterolf

ABSTRACT

The effect of ZnO on sheet-iron cover-enamel properties was studied by evaluation of the properties of a typical sheet-iron cover enamel in which ZnO was used as single- and double-partial replacements for the various ingredients. The fluxing action of ZnO was found to be pronounced and it was markedly effective in decreasing frit solubility in the mill liquor. Improvement in gloss resulted from its use without any adverse effect on enamel extensibility and resistance to thermal shock.

## I. Introduction

The use of zinc oxide in cast-iron enamels is very general, but its value as a sheet-iron cover-enamel constituent has not been so fully established inasmuch as many compositions of this type contain little or none of the compound. This uncertainty as to the specific rôle of zinc oxide in sheet-iron enamels has led to a rather comprehensive laboratory investigation of the possible merits of the compound in this type of enamel.

## II. Outline of Investigation

There was selected as a basis for study, a sheet-iron cover-enamel composition typical of most of the enamels of this type now in use. This composition was as follows:

| | (%) | | (%) |
|---|---|---|---|
| $Na_2O$ | 9.2 | $SiO_2$ | 45.0 |
| $K_2O$ | 5.7 | $CaF_2$ | 5.0 |
| $B_2O_3$ | 11.6 | $Na_3AlF_6$ | 12.5 |
| $Al_2O_3$ | 6.0 | $NaSbO_3$ | 5.0 |

The effect of zinc oxide was compared with that of the other melted constituents by means of two series of enamels (1) 3% zinc oxide substituted for 3% of each of the melted constituents of the parent enamel taken singly and (2) 6% zinc oxide substituted for 3% of each of two constituents in all possible combinations. It was felt that such a method would show which common enamel ingredient or ingredients might be advantageously replaced in part by zinc oxide. Following the determination of the effect on enamel properties of single- and double-partial replacements, enamels were compounded in the light of these findings by distributing small partial replacements over a greater number of the constituents of the parent enamel.

## III. Methods

**(1) Preparation of Enamels** Enamels were made up in the usual laboratory manner, particular care being exercised to maintain uniform smelting treatment for all enamels. They were milled to a fineness of 3 to 4% on 200-mesh on the basis of wet weight of enamel. Fineness of milled enamels was carefully adjusted to this value because of the importance of this factor as related to frit solubility.

**(2) Solubility in Mill Liquor** Frit solubilities were determined after aging periods of 1 to 30 days by titration of $Na_2O$ with $N/10$ HCl to the methyl red end-point and by titration of

* Presented at the Annual Meeting, American Ceramic Society, Pittsburgh, Pa., February, 1933 (Enamel Division).

$B_2O_3$ with $N/10$ NaOH to the phenolphthalein end-point with the intermediate addition of glycerine.

It is well known that commercially milled enamels develop much higher frit solubilities than the same enamels milled in laboratory-size mill jars. Defects caused by excessive solubility are consequently more likely to develop in commercial practice. In order to increase frit solution to a point more nearly comparable with plant results, samples of enamel aged normally 30 days were heated in sealed containers for 8 hours at 70°C, and the supernatant mill liquor was withdrawn and titrated. The procedure apparently gave solubility results closely approximating those obtained under plant milling conditions.

The relation between soluble salt contents of mill liquors and enamel-pitting tendencies was determined by applying the specially treated enamels on test plates in coats of uniform weight, drying slowly in an atmosphere of high humidity, and firing.

**(3) Fusibility Tests** Enamels were compared with respect to fusibility by means of cone deformation tests. This test was found to be more delicate than the several other fusibility tests which have been employed recently for enamels and was found to give check results within 4 or 5°F, providing the method of forming cones, heating rate, etc., were carefully standardized and adhered to.

**(4) Thermal Shock** Resistance to thermal shock was determined by means of the method recently described by Kinzie.[1]

## IV. Results

**(1) Fusibility** The effect of zinc oxide on enamel fusibility is shown in Table IA which gives the cone deformation temperatures of the various enamels containing zinc-oxide substitutions for the different ingredients in amounts indicated by the headings of the vertical and horizontal columns. Comparison of these temperatures with the deformation temperature of the parent enamel, which was 1252°F, indicates definitely the vigorous fluxing action of zinc oxide. An increase in fusibility resulting from substitution of zinc oxide for such refractory con-

TABLE IA

EFFECT OF ZINC OXIDE SUBSTITUTIONS ON CONE DEFORMATION TEMPERATURES*

| Zinc oxide substituted for 3% of each of the following constituents | 3% $Na_2O$ | 3% $K_2O$ | 3% $B_2O_3$ | 3% $Al_2O_3$ | 3% $SiO_2$ | 3% $CaF_2$ | 3% $Na_3AlF_6$ | 3% $NaSbO_3$ |
|---|---|---|---|---|---|---|---|---|
| | 1231°F | 1227 | 1243[a] | 1242 | 1216 | 1227 | 1233 | 1228 |
| $K_2O$ | 1228 | | | | | | | |
| $B_2O_3$ | 1238[a] | 1231[a] | | | | | | |
| $Al_2O_3$ | 1238 | 1222 | 1243[a] | | | | | |
| $SiO_2$ | 1221 | 1210 | 1227[a] | 1218 | | | | |
| $CaF_2$ | 1224 | 1219 | 1236[a] | 1222 | 1204 | | | |
| $Na_3AlF_6$ | 1225 | 1227 | 1228[a] | 1225 | 1202 | 1200 | | |
| $NaSbO_3$ | 1214 | 1223 | 1232[a] | 1223 | 1193 | 1213 | 1211 | |

* Deformation temperature of the parent enamel, 1252°F.

[a] For example, the eight enamels marked (*a*) have 3% ZnO substituted for 3% $B_2O_3$ and 3% of each of the other ingredients, in order.

[1] *Jour. Amer. Ceram. Soc.*, **12** [3], 188–92 (1929).

stituents as $Al_2O_3$ and $SiO_2$ might be expected, but the softening effect was not confined to enamels containing such replacements. All enamels containing zinc oxide, regardless of the manner of substitution, showed increased fusibility, and the efficacy of zinc oxide when substituted for the fluxes, $Na_2O$,$Na_3AlF_6$, and $CaF_2$, was almost as pronounced as when it was substituted for equal percentages of the refractory constituents. The fluxing effect was least pronounced in cases of substitution of zinc oxide for $B_2O_3$.

TABLE IB

| Substitution of zinc oxide in the parent enamel for 3% of each of the following constituents | Average cone deformation* temperature of 8 enamels (°F) | Reduction in cone deformation temperature (°F) |
|---|---|---|
| $Na_2O$ | 1227 | 25 |
| $K_2O$ | 1223 | 29 |
| $B_2O_3$ | 1233 | 19 |
| $Al_2O_3$ | 1227 | 25 |
| $SiO_2$ | 1211 | 41 |
| $CaF_2$ | 1217 | 35 |
| $Na_3AlF_6$ | 1217 | 35 |
| $NaSbO_3$ | 1215 | 37 |

* Deformation temperature of the parent enamel, 1252°F.

By referring to Table IA showing the zinc-oxide substitutions indicated by the headings of the vertical and horizontal columns, it is seen that there were eight enamels (refer to note (*a*) under Table IA) in which 3% zinc oxide replaced 3% $Na_2O$, eight enamels in which 3% zinc oxide replaced 3% $K_2O$, and so on for each melted constituent. Table IB gives the average cone deformation temperature of the eight enamels involving zinc-oxide replacements for $Na_2O$, likewise the average deformation temperature of each set of eight enamels involving zinc-oxide replacements for 3% of each of the remaining melted constituents. The deformation temperature of each enamel containing double replacements is, of course, used twice in the determination of averages. The results tabulated serve to indicate the relative fluxing effects of zinc oxide when substituted for each of the constituents.

**(2) Solubility in Mill Liquor** The effect of zinc-oxide replacements on solubility of frit in mill liquor was, in general, quite as pronounced as that on fusibility. In Table II are given the $Na_2O$ and $B_2O_3$ contents in grams per 10 cubic centimeters of mill liquor aged both 1 and 30 days. Comparing the solubilities of the various individual enamels with that of the basic enamel, it is observed that with few exceptions, zinc oxide reduced the frit solubility. In some cases solubility was reduced to one-half and even one-third. The few exceptions were enamels containing zinc oxide at the expense of $Al_2O_3$ and/or $SiO_2$, both of which normally stabilize a glass in this respect.

The solubility results obtained indicate that a typical sheet-iron enamel glass may be greatly stabilized by the judicious use of zinc oxide. The importance of frit solubility has been pointed out by Danielson,[2] both from the standpoints of suspensive properties of the enamel and pitting as related to excessive frit solubility and crystallization of soluble salts during

[2] *Jour. Amer. Ceram. Soc.*, **12** [8], 538–47 (1929).

drying. The solubilities of all the enamels as given are without doubt too low to be a direct cause of pitting. It must be remembered, however, that plant milling would greatly increase frit solubilities and the enamels indicated as having low solubilities would be less likely to develop defects under adverse drying conditions. This point was proved by increasing solution of

TABLE II

SOLUBILITIES OF NORMALLY AGED ENAMELS

| Zinc oxide substituted for 3% | 3% | Aged 1 day $Na_2O$ | Aged 1 day $B_2O_3$ | Aged 30 days $Na_2O$ | Aged 30 days $B_2O_3$ |
|---|---|---|---|---|---|
| | | 0.027 | 0.021* | 0.032 | 0.038* |
| $Na_2O$ | | .017 | .016 | .018 | .027 |
| $K_2O$ | | .017 | .014 | .021 | .027 |
| $B_2O_3$ | | .025 | .013 | .024 | .021 |
| $Al_2O_3$ | | .028 | .020 | .033 | .039 |
| $SiO_2$ | | .026 | .020 | .032 | .042 |
| $CaF_2$ | | .016 | .016 | .020 | .030 |
| $Na_3AlF_6$ | | .016 | .017 | .016 | .023 |
| $NaSbO_3$ | | .025 | .016 | .026 | .033 |
| $Na_2O$– | $K_2O$ | .009 | .014 | .010 | .024 |
| $Na_2O$– | $B_2O_3$ | .021 | .013 | .019 | .021 |
| $Na_2O$– | $Al_2O_3$ | .022 | .020 | .023 | .039 |
| $Na_2O$– | $SiO_2$ | .017 | .019 | .019 | .035 |
| $Na_2O$– | $CaF_2$ | .011 | .014 | .014 | .026 |
| $Na_2O$– | $Na_3AlF_6$ | .010 | .015 | .013 | .026 |
| $Na_2O$– | $NaSbO_3$ | .012 | .015 | .017 | .028 |
| $K_2O$– | $B_2O_3$ | .017 | .009 | .018 | .020 |
| $K_2O$– | $Al_2O_3$ | .021 | .014 | .022 | .034 |
| $K_2O$– | $SiO_2$ | .015 | .016 | .022 | .035 |
| $K_2O$– | $CaF_2$ | .010 | .017 | .017 | .030 |
| $K_2O$– | $Na_3AlF_6$ | .009 | .013 | .014 | .024 |
| $K_2O$– | $NaSbO_3$ | .013 | .016 | .017 | .028 |
| $B_2O_3$– | $Al_2O_3$ | .023 | .015 | .026 | .025 |
| $B_2O_3$– | $SiO_2$ | .023 | .015 | .024 | .022 |
| $B_2O_3$– | $CaF_2$ | .013 | .012 | .017 | .018 |
| $B_2O_3$– | $Na_3AlF_6$ | .014 | .011 | .014 | .015 |
| $B_2O_3$– | $NaSbO_3$ | .023 | .013 | .023 | .021 |
| $Al_2O_3$– | $SiO_2$ | .028 | .026 | .032 | .044 |
| $Al_2O_3$– | $CaF_2$ | .016 | .017 | .021 | .031 |
| $Al_2O_3$– | $Na_3AlF_6$ | .017 | .017 | .020 | .031 |
| $Al_2O_3$– | $NaSbO_3$ | .023 | .021 | .029 | .039 |
| $SiO_2$– | $CaF_2$ | .014 | .019 | .024 | .035 |
| $SiO_2$– | $Na_3AlF_6$ | .020 | .020 | .024 | .030 |
| $SiO_2$– | $NaSbO_3$ | .023 | .021 | .026 | .032 |
| $CaF_2$– | $Na_3AlF_6$ | .011 | .015 | .014 | .022 |
| $CaF_2$– | $NaSbO_3$ | .014 | .016 | .018 | .023 |
| $Na_3AlF_6$– | $NaSbO_3$ | .014 | .016 | .017 | .023 |

* Parent enamel.

frits artificially by aging in sealed containers for eight hours at 70°C, spraying samples, drying in a humid atmosphere, and firing. Enamels for which high solubilities are given in Table II were those which developed pitting after being given this special treatment.

**(3) Gloss** The enamel literature refers repeatedly to the value of zinc oxide in increasing gloss by virtue of the high index of refraction imparted to glass by its use. The series of enamels studied definitely showed a contribution of zinc oxide to this property. The oxide was

slightly effective when used to the extent of 3% for the alkalis, fluorspar, or cryolite. Improvement in gloss was very decided when used as a 6% replacement for 3% of each of two constituents and more particularly in those enamels involving zinc oxide replacements for the fluxes above-mentioned.

**(4) Extensibility** Cross-bending tests were made on some of the enamels of the series to determine a possible effect of zinc oxide on enamel extensibility. It was observed that zinc oxide affected this property, as measured by the well-known cross-bending test, only insofar as it influenced the coefficient of expansion of the enamel. This relationship is in agreement with the results obtained by Gautsch[3] in a study specifically designed to show the dependence of ability of enamels to withstand flexure upon their coefficients of expansion.

An interesting exception was observed in the cases of enamels containing zinc-oxide replacements for $Al_2O_3$. The flexure withstood by these enamels was consistently much less than a general relationship between flexure at failure and calculated coefficient of expansion would require. One of two explanations might account for this particular discrepancy: either some unusual influence of $Al_2O_3$ on enamel extensibility or inapplicability of the empirical factors for calculating coefficient of expansion in cases of enamels modified by substitution of zinc oxide for a part of the normal $Al_2O_3$ content.

TABLE III

RELATIONSHIP BETWEEN COEFFICIENT OF EXPANSION AND TYPE OF CRAZING

| Calculated expansion $\times 10^{-7}$ | Number of enamels | Average rating |
|---|---|---|
| 290–299 | 3 | 1.0 coarse crazing |
| 300–309 | 7 | 1.5 |
| 310–319 | 8 | 2.6 |
| 320–329 | 9 | 3.0 |
| 330–339 | 9 | 3.7 |
| 340–350 | 1 | 4.0 fine crazing |

**(5) Resistance to Thermal Shock** Thermal shock tests, made by allowing cold water to drop at the rate of three drops per minute for 10 minutes on enameled plates, held at 600°F, showed a definite relationship between the resultant type of crazing and coefficient of thermal expansion. Low-expansion enamels were characterized by crazing of very coarse mesh while a fine network of crazing was typical of high-expansion enamels. The relationship is indicated by the average ratings of enamels falling within the calculated expansion intervals shown in Table III. Enamels were rated from one to four, depending upon the type of crazing.

Most enamels having expansions greater than 325 developed crazes radiating from the area subjected to thermal shock, while crazing in enamels of lower expansion was in every case confined to the area of contact between water and enamel.

All enamels involving replacements of $Al_2O_3$ were exceptions to the otherwise consistent relationship between coefficient of expansion and type of crazing. These enamels developed the fine crazing typical of enamels of

[3] *Jour. Amer. Ceram. Soc.*, **15** [1], 8–12 (1932).

much higher coefficients of expansion. It will be recalled that the same enamels gave cross-bending results in line with results obtained on enamels of much higher expansions. There appears to be evidence that partial elimination of $Al_2O_3$ from an enamel of the type under study resulted in a marked change in some enamel property, possibly a greatly increased coefficient of expansion. It would be interesting to learn whether the change was peculiar only to a partial zinc-oxide replacement for $Al_2O_3$ or would have been characteristic of other additions at the expense of $Al_2O_3$.

## V. Value of Zinc Oxide as a Sheet-Iron Enamel Constituent

It is realized that zinc oxide can not be used promiscuously in the replacement of ingredients as has been done in this study. For example, replacement of 3% $Na_2O$ and 3% $Na_3AlF_6$ would reduce expansion below a safe limit, while replacement of 3% $NaSbO_3$ would be at the expense of opacity. The benefits of zinc oxide may, however, be obtained by replacement of 1 to 2% of each of a number of constituents selected in such a manner as to maintain correct expansion. Enamels based on the typical composition given have been compounded in such a manner and have shown the definite advantages of increased fusibility, superior gloss, lowered frit solubility, and, in many cases, increased acid resistance without impairment of opacity in spite of replacement of several per cent of the fluorides. A suggested revision of a typical sheet-iron enamel composition to obtain the named advantages is substitution of zinc oxide for 1% $Na_2O$, 2% $B_2O_3$, 1% $SiO_2$, 1% $CaF_2$, and 1% $Na_3AlF_6$. Such a modification of the typical enamel studied results in a negligible change in coefficient of expansion, in an increase in fusibility corresponding to a reduction in cone deformation temperature of more than 20°F, and in reduction of frit solubility to about one-half for both $Na_2O$ and $B_2O_3$.

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# X-RAY INVESTIGATION OF THE OPACIFYING COMPOUNDS PRESENT IN SHEET-IRON COVER ENAMELS*

By Andrew I. Andrews and J. P. Breen

ABSTRACT

By the use of X-ray methods, sheet-iron cover-enamel frits and fired enamels were investigated. The results obtained show that tin oxide exists as tin dioxide in the enamel, antimony as antimony pentoxide, fluorspar as calcium fluoride, and cryolite as sodium fluoride. Zirconium oxide does not exist as the crystalline zirconium oxide even when present as a mill addition. Variations in the compositions of the ordinary sheet-iron cover enamels do not affect the identity of the crystals.

## I. Introduction

This investigation is an application of X-ray methods to the determination of the opacifiers in sheet-iron cover enamels.

It has already been reported[1] that the opacity in dry-process cast-iron enamels is caused primarily by crystalline substances finely distributed through the enamel glass. To check these results for other types of enamels and to search further into the fundamentals of the development of opacity, the present investigation was undertaken.

**(1) Literature** Until recently there has been little exact information available concerning the causes of opacity. Many writers, however, have presented theories upon the subject with reference to enamels, glasses, and glazes. Lehmann, Agde, and Krause[1] stated that when aluminum fluoride ($AlF_3$) or sodium fluoride (NaF) were used, NaF separated from the cooling magma to produce turbidity. When fluorspar was used, the opacity was the result of the separation of calcium fluoride ($CaF_2$) and sodium fluoride (NaF). Hyslop[2] pointed out that if clear threads of an opal glass mixture were heated from 700 to 1200°F in five hours, a crystalline fluoride appeared. Zschimmer[3] held that the opalescence of glasses was caused by spheroids of fluorine compounds. Ryde and Yates[4] stated that the opacity of opal glasses was the result of sodium fluoride and calcium fluoride. Andrews, Clark, and Alexander[5] showed by X-ray methods that the opacity in dry-process cast-iron enamels was caused by crystalline NaF, $CaF_2$, $Sb_2O_5$, ZnS, $Ca_3(PO_4)_2$, or combinations of these.

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* Presented at the Annual Meeting, American Ceramic Society, Pittsburgh, Pa., February, 1933 (Enamel Division).

[1] (*a*) W. M. Lehmann, G. Agde, and H. F. Krause, "Behavior of Fluorides in Glasses and Enamels," *Z. angew. Chem.*, **40**, 804 (1927); *Chem. & Ind.*, **46B**, 654 (1927); Enamel Bibliography, p. 1.

(*b*) G. Agde and H. F. Krause, "Study of Behavior of Fluoride Additions to Glasses and Enamels," *Z. angew. Chem.*, **40**, 525–33 (1927); Enamel Bibliography, p. 1.

(*c*) G. Agde and H. F. Krause, "Effects of Fluoride Additions to Glasses and Enamels: The Causes of Fluorine Losses during the Smelting of Glasses and Enamels with Fluorine Additions," *Z. angew. Chem.*, **40**, 886–95 (1927); Enamel Bibliography, p. 1.

[2] I. F. Hyslop, "Opal Glass. Crystal Growth and Impact Brittleness," *Jour. Soc. Glass Tech.*, **11**, 362 (1927).

[3] E. Zschimmer, "Fluor-Opal and the Theory of Opaque Glasses Used in the Illuminating Industry," *Sprechsaal*, pp. 347–49, 354–56 (1930); *Chem. Abs.*, **24**, 3517 (1930).

[4] Ryde and Yates, "Opal Glass," *Jour. Soc. Glass Tech.*, **10** [39], 274–94 (1927).

[5] A. I. Andrews, G. L. Clark, and H. W. Alexander, "Progress Report on Determination of Crystalline Compounds Causing Opacity in Enamels by X-Ray Methods," *Jour. Amer. Ceram. Soc.*, **14** [9], 634 (1931); "Determination of Crystalline Compounds Causing Opacity in Enamels by X-Ray Methods" (to be published in this *Journal* August, 1933).

## II. Opacity in Sheet-Iron Enamels

The scope of the present investigation was limited to variations in the enamel glass composition, variations in the opacifiers added to the raw batch, and variations in the opacifiers added at the mill in sheet-iron cover enamels.

The feldspar, borax, and quartz contents in the enamel glass were varied

TABLE I

RESULTS AND COMPOSITIONS

| Compositions | Substitutions in feldspar, quartz, and borax | | | | Substitutions in opacifiers | | | | | | | | Fritted to transparency | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Raw batch | 1 | 2 | 3 | 4 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 010 | 011 | 012 |
| Feldspar | 25 | 30 | 25 | 40 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 25 | 25 | 25 | 25 |
| Quartz | 15 | 20 | 30 | 15 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 15 | 15 | 15 | 15 |
| Borax | 36 | 26 | 21 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 36 | 36 | 36 | 36 |
| Sodium carbonate | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Sodium nitrate | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Fluorspar | 3 | 3 | 3 | 3 | 3 | 3 | 11 | 0 | 8.5 | 5.7 | 8.5 | 0 | 17 | | | |
| Cryolite | 11 | 11 | 11 | 11 | 11 | 3 | 3 | 8.5 | 0 | 5.6 | 8.5 | 17 | | 17 | | |
| Antimony oxide | 3 | 3 | 3 | 3 | 3 | 11 | 3 | 8.5 | 8.5 | 5.7 | 0 | 0 | | | 17 | |
| Tin oxide | | | | | | | | | | | | | | | | 17 |
| **Results Frits** | | | | | | | | | | | | | | | | |
| $CaF_2$ | ×* | × | × | × | × | × | × | –† | × | × | × | – | – | – | – | – |
| NaF | × | × | × | × | × | × | × | × | – | × | × | × | – | – | – | – |
| $Sb_2O_5$ | × | × | × | × | × | × | × | × | × | × | – | – | – | – | – | – |
| $SnO_2$ | | | | | | | | | | | | | – | – | – | – |
| **Frits + Mill A (7% tin oxide and 5% clay)** | | | | | | | | | | | | | | | | |
| $CaF_2$ | × | × | × | × | × | × | × | – | × | × | × | – | | | | |
| NaF | × | × | × | × | × | × | × | – | – | × | × | × | | | | |
| $Sb_2O_5$ | × | × | × | × | × | × | × | × | × | × | – | – | | | | |
| $SnO_2$ | × | × | × | × | × | × | × | × | × | × | × | × | | | | |
| $ZrO_2$ | – | – | – | – | – | – | – | – | – | – | – | – | | | | |
| **Frit + Mill B (7% Opax and 5% clay)** | | | | | | | | | | | | | | | | |
| $CaF_2$ | × | × | × | × | × | × | × | – | × | × | × | – | | | | |
| NaF | × | × | × | × | × | × | × | – | – | × | × | × | | | | |
| $Sb_2O_5$ | × | × | × | × | × | × | × | × | × | × | – | – | | | | |
| $SnO_2$ | – | – | – | – | – | – | – | – | – | – | – | – | | | | |
| $ZrO_2$ | – | – | – | – | – | – | – | – | – | – | – | – | | | | |

* × = yes; † – = no.

over a range of 15% as shown in enamels 1, 2, 3, and 4 of Table I. The variations of the opacifiers added to the raw batch consisted of 17% fluorspar, antimony oxide, and cryolite as shown in compositions 01, 02, 03, 04, 05, 06, 07, and 08 of Table I.

Two different mill batches were used for all of these enamels, one (A) containing 7% tin oxide and the other (B) containing 7% Opax (zirconium oxide).

The four compositions 09, 010, 011, and 012 were smelted until all of the opacity was destroyed.

## III. Procedure

The raw frit batches given in Table I were prepared by the ordinary laboratory methods of smelting and milling. The mill additions, A and B, of Table I were used and the slip milled to pass a No. 80 sieve with a small residue on a No. 100 sieve.

Samples for X-ray analysis were obtained by bending the fired plates to produce chips of the enamel coating. By selecting chips not contaminated with ground coat, the samples for X-ray examination were obtained.

These X-ray samples were prepared by powdering the enamel in an agate mortar to pass a No. 250 sieve. The powdered enamel was then placed in capillary glass tubes about one-half millimeter in diameter. The X-ray study of each sample was made on a General Electric multiple diffraction apparatus. Exposure time was about forty-eight hours although a deviation was necessary in some cases to obtain a distinct pattern.

The crystalline compounds present were identified by comparing these patterns with those of known crystalline materials. In the case of zirconium enamels, patterns were made both with and without the zirconium-oxide filter in the machine but no difference showed in the results.

## IV. General Discussion of Results

The results of the X-ray tests of the enamels are tabulated in Table I.

The variations of feldspar, borax, and quartz in the enamel composition had no effect on the identity of the crystalline compounds showing opacity. It is quite probable, therefore, that the composition of the enamel glass had little if any effect on the nature of the crystalline compounds causing opacity. These results are shown by the enamels 1 to 4 in Table I.

The variations of fluorspar, antimony oxide, and cryolite showed that each contributed to the crystalline compounds present in the enamel. Fluorspar was present in these sheet-iron enamels as calcium fluoride, antimony oxide was present as antimony pentoxide, and cryolite contributed crystalline sodium fluoride. If any one or more of these compounds were present in an enamel, the enamel was opaque. When tin oxide was added to the mill, crystals of the same appeared in the X-ray pattern. The zirconium oxide (Opax) enamel, however, did not show the presence of zirconium oxide and although the enamel was made opaque no crystalline particles showed in X-ray tests.

It is necessary to theorize to explain this phenomenon and the probable explanation is as follows: The zirconium oxide in the enamel reacts with the glass and forms small globules of a zirconium glass of high index of refraction. Since those globules are not very soluble or miscible in the enamel glass, they may be retained as such, giving the opacity contributed to enamel by zirconium oxide additions.

The transparent frits made by smelting the opacity out of the enamels showed no crystalline compounds although cryolite, fluorspar, antimony oxide, and tin oxide were present in the raw batch. This proved that the opacity obtained by these compounds was caused by the crystallites.

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# THE THERMAL EXPANSION OF SHEET-IRON GROUND-COAT ENAMELS*

By Andrew I. Andrews and Robert K. Smith

ABSTRACT

The thermal expansions of sheet-iron ground-coat enamels were determined by use of the interferometer. The results showed that the calculated expansions based on the factors of Mayer and Havas were close to the actual expansions. It was also shown that variations of borax, feldspar, and quartz resulted in a fairly uniform change in the expansion. It was possible to interpolate between values for these constituents. The softening of the enamels in the interferometer test proved to be a characteristic change depending on the fusibility of the enamel. These data showed promise as a test for fusibility.

## I. Introduction

Although several investigators have systematically attempted to correlate chemical composition with the coefficient of expansion of glass, all have used the principle of a permutating oxide. The present method is based on the fact that a large portion of the known batch compositions of sheet-iron ground-coat enamels lies within the limits of a comparatively small field on a triaxial composition diagram of which borax, feldspar, and quartz were the end members. To this portion of variables (81%) there was added a constant portion (19%) of other necessary materials.

This investigation was intended to furnish experimental data on the coefficients of thermal expansion of enamels in the above-mentioned field, from which the values of other enamels in the same field could be determined by interpolation.

It was also intended to determine the effect of the solution of iron during firing upon the coefficient of thermal expansion of the enamel.

## II. Review of Literature

While the literature reveals several investigations of the relationship between composition and physical properties of glass, few of the glasses studied could be considered as representative of sheet-iron ground-coat enamels.

The first record of a systematic attack on the problem is an account of the work of Winkelmann and Schott,[1] who asserted the approximate additivity of oxide factors for the cubical coefficient of expansion of glasses and determined factors for some of the more commonly used oxides. These factors, for convenience of calculation, were made to represent the contribution of 1% oxide to the total expansion of the glass. The product of the factor of any oxide and the percentage of the oxide in the glass was a value which, when added to the similarly obtained values for the other oxides present, was approximately the correct cubical coefficient of expansion of the glass. It is noteworthy that the factors of Winkelmann and Schott showed a variation of ±11% between the calculated and observed values of expansion even in the glasses of the original investigation. It is evident that these factors have been assumed to be more accurate than was the authors' intention.

Later investigations by Mayer and Havas[2] supplemented the work of

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[1] Winkelmann and Schott, *Wiedmann Annalon Bd.*, **51**, 731 (1894).

[2] Mayer and Havas, *Sprechsaal*, **42**, 497 (1909); *ibid.*, **44**, 188, 207.

Winkelmann and Schott with determinations on several enamel compositions. They checked the Winkelmann and Schott factors and extended their investigation to include a number of new oxides. The investigation of Mayer and Havas today remains the most complete ever undertaken.

English and Turner,[3] assuming that silica carried the expansion of fused quartz into glass, calculated a new set of factors which differed considerably from those previously published.

F. P. Hall,[4] working at the Bureau of Standards, determined factors for some of the common glaze oxides.

TABLE I

RESULTS OF PREVIOUS INVESTIGATIONS EXPRESSED AS OXIDE FACTORS FOR CALCULATION OF THERMAL EXPANSION

| Oxide | Winkelmann and Schott[a] | Mayer and Havas[b] | English and Turner[c] | Fetterolf and Parmelee[d] | Hall[e] |
|---|---|---|---|---|---|
| $SiO_2$ | 0.8 | 0.8 | 0.15 | 0.15 | (0.15–1.5)[f] |
| $Al_2O_3$ | 5.0 | 5.0 | 0.42 | | 1.50 |
| $B_2O_3$ | 0.1 | 0.1 | −1.98 | | 0.6 |
| $As_2O_5$ | 2.0 | 2.0 | | | |
| $P_2O_5$ | 2.0 | 2.0 | | | |
| $Na_2O$ | 10.0 | 10.0 | 12.96 | 12.5 | 11.4 |
| $K_2O$ | 8.5 | 8.5 | 11.7 | | 9.0 |
| PbO | 3.0 | 4.2 | 3.18 | | 2.25 |
| ZnO | 1.8 | 2.1 | 2.1 | 1.85 | 3.0 |
| CaO | 5.0 | 5.0 | 4.89 | | 4.5 |
| MgO | 0.1 | 0.1 | 1.35 | | 0.6 |
| BaO | 3.0 | 3.0 | 4.2 | 5.7 | 3.6 |
| $Na_3AlF_6$ | | 7.4 | | | |
| NaF | | 7.4 | | | |
| $Cr_2O_3$ | | 5.1 | | | |
| CaO | | 4.4 | | | |
| $AlF_3$ | | 4.4 | | | |
| $TiO_2$ | | 4.1 | | | |
| $Fe_2O_3$ | | 4.0 | | | |
| NiO | | 4.0 | | | |
| $Sb_2O_5$ | | 3.6 | | | |
| $CaF_2$ | | 2.5 | | | |
| $MnO_2$ | | 2.2 | | | |
| $SnO_2$ | | 2.0 | | | |
| CuO | | 2.2 | | | |

[a] See footnote 1. [b] See footnote 2. [c] See footnote 3. [d] See footnote 5. [e] See footnote 4. [f] Hall found that the factor for silica varied from 0.15 at 100% to 1.5 at 0% $SiO_2$.

Fetterolf and Parmelee,[5] working from the same basic assumption as English and Turner, thoroughly investigated the action of several oxides over a wide range of composition and calculated some new factors for these oxides.

Several other investigators[6] have published data on the expansion of various glasses without attempting the calculation of oxide factors.

Table I is a summary of the oxide factors derived by the workers indicated. Comparison would seem to indicate that these factors were not constant, but varied with the composition of the glass.

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[3] English and Turner, *Jour. Soc. Glass Tech.*, **4**, 115 (1920).

[4] Hall, *Jour. Amer. Ceram. Soc.*, **13**, 182 (1930).

[5] L. D. Fetterolf and C. W. Parmelee, *ibid.*, **12**, 193 (1929).

[6] (*a*) Peters and Cragoe, Bur. Stand., *Sci. Paper*, No. 393; (*b*) Danielson and Souder, *Jour. Amer. Ceram. Soc.*, **4**, 620 (1921); (*c*) Samsoen, *Compt. rend.*, **183**, 285 (1926).

## III. Experimental Procedure

The enamel compositions are given in Table II. The feldspar used had the following composition:

| | (%) |
|---|---|
| Ignition loss | 1.58 |
| $SiO_2$ | 65.2 |
| $Al_2O_3$ | 19.78 |
| $Fe_2O_3$ | 0.075 |
| CaO | 0.34 |
| $K_2O$ | 11.99 |
| $Na_2O$ | 1.55 |
| | 100.515 |

Each time new batches were weighed, the borax was crushed, sifted through a No. 20 standard sieve, mixed, and the water content of a sample determined. The remainder of the materials used were assumed to be pure.

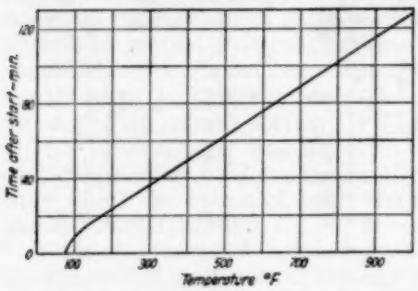


FIG. 1.—Firing curve for interferometer furnace.

The ingredients were weighed in 1500-gram batches, the individual weights being accurate to ±0.1 gram and to ±0.01 gram in the case of the color oxides. The batches were sifted through a No. 20 standard sieve and thoroughly mixed by rolling on a square of paper. The batches were smelted in tightly covered fireclay crucibles placed in a Globar electric furnace[7] and held at a temperature from 1850 to 2100°F, varying with the fusibility of the enamel. When a smooth thread could be drawn from the molten mass, after from three to five hours of smelting, the frit was removed from the furnace and quenched by pouring slowly into water. The water was immediately poured off to minimize any possible solution of the frit and the frit was placed in a drier at 110°C.

When dry, the frit was dry ground in a ball mill to pass a No. 60 standard sieve and the ground frit was thoroughly mixed by rolling on a square of paper. Approximately 50 grams of the mixture was then remelted in a platinum crucible, the melting being done in a small, vertical, platinum resistance, tubular electric furnace.

After the glass had been held in a fluid condition, with frequent stirring, for about an hour, the temperature was lowered until the glass was sufficiently viscous to allow the drawing of a rod approximately $^1/_8$ inch in diameter from the melt. This rod, about six inches long, was placed in an electric muffle furnace, 14 by 7 by 5 inches, controlled by a Leeds and Northrup recorder controller. A small thread of the same frit, six inches long by $^1/_{32}$ inch in diameter, was supported in cantilever fashion at one end and placed in the same furnace. The temperature of the furnace was then raised sufficiently to cause the small rod to bend. The temperature was held constant for 15 minutes to allow for the adjustments of strains.

[7] Andrews and Alexander, Univ. of Ill., Eng. Expt. Sta., *Bull.*, No. 227.

This temperature is noted in Table IV as the annealing temperature. The furnace was allowed to cool gradually to room temperature in eight hours.

When cool, the rod was removed from the furnace and ground to a blunt point with silicon carbide powder on a Lapp wheel. The rod was then scratched with a file and broken off about $^1/_2$ centimeter below the point. This process was repeated until six pointed specimens were obtained. The bases of these specimens were ground to a plane surface and the bases of three were further ground on a fine silicon carbide stone until the heights were the same within 0.0002 centimeter, when measured by a micrometer caliper.

The three specimens were placed in the interferometer and the heights still further adjusted until there were from eight to twelve fringes in the field of view. When a satisfactory field was obtained, the specimens were removed, measured accurately by the micrometer caliper, and replaced in the interferometer.

The interferometer was placed in a small, vertical, chromel resistance, tubular electric furnace. The temperature of the furnace was then raised according to

TABLE II

RAW BATCH AND MELTED OXIDE COMPOSITIONS OF ENAMELS

| | Batch Weights | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | Max. | Min. | Avg. | Med. | $^1/_2$ | Range |
| Feldspar | 20.00 | 30.00 | 26.67 | 23.33 | 33.33 | 20.00 | 30.00 | 40.00 | 26.67 | 36.67 | 33.33 | 30.00 | 40.00 | 40.00 | 20.00 | 30.00 | 30.00 | 30.00 | 20.00 |
| Borax | 41.00 | 41.00 | 37.67 | 34.33 | 34.33 | 31.00 | 31.00 | 31.00 | 27.67 | 27.67 | 24.33 | 21.00 | 21.00 | 21.00 | 21.00 | 31.00 | 31.00 | 31.00 | 20.00 |
| Flint | 20.00 | 10.00 | 16.67 | 23.33 | 13.33 | 30.00 | 20.00 | 10.00 | 26.67 | 16.67 | 23.33 | 30.00 | 20.00 | 30.00 | 10.00 | 20.00 | 20.00 | 20.00 | 20.00 |
| Soda ash | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 | 0.00 |
| Soda niter | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 0.00 |
| Fluorspar | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 0.00 |
| Cobalt oxide | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.00 |
| Manganese dioxide | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 | 0.00 |
| | Melted Weights | | | | | | | | | | | | | | | | | | |
| $Na_2O$ | 16.72 | 16.92 | 15.82 | 14.73 | 14.95 | 13.70 | 13.90 | 14.10 | 12.90 | 13.12 | 12.14 | 11.20 | 11.40 | 16.92 | 11.20 | 13.97 | 13.90 | 14.06 | 5.72 |
| $K_2O$ | 3.20 | 4.81 | 4.18 | 3.58 | 5.13 | 3.01 | 4.52 | 6.04 | 3.94 | 5.41 | 4.84 | 4.27 | 5.69 | 6.04 | 3.01 | 4.51 | 4.52 | 4.53 | 2.68 |
| CaO | 0.09 | 0.13 | 0.12 | 0.10 | 0.14 | 0.09 | 0.13 | 0.18 | 0.11 | 0.15 | 0.13 | 0.12 | 0.17 | 0.18 | 0.09 | 0.13 | 0.13 | 0.14 | 0.09 |
| $Al_2O_3$ | 5.28 | 7.94 | 6.88 | 5.91 | 8.44 | 4.97 | 7.45 | 9.95 | 6.49 | 8.94 | 7.96 | 7.03 | 9.40 | 9.95 | 4.97 | 7.43 | 7.45 | 7.46 | 4.98 |
| $B_2O_3$ | 20.00 | 20.03 | 18.02 | 16.10 | 16.12 | 14.24 | 14.25 | 14.27 | 12.49 | 12.50 | 10.77 | 9.12 | 9.13 | 20.03 | 9.12 | 14.39 | 14.25 | 14.58 | 10.91 |
| $SiO_2$ | 44.03 | 39.46 | 44.52 | 49.38 | 45.07 | 54.00 | 49.63 | 45.42 | 54.30 | 50.00 | 54.40 | 58.85 | 54.73 | 58.85 | 39.46 | 49.53 | 49.65 | 49.16 | 19.39 |
| $CaF_2$ | 8.00 | 8.02 | 7.84 | 7.68 | 7.70 | 7.53 | 7.54 | 7.55 | 7.39 | 7.40 | 7.25 | 7.11 | 7.12 | 8.02 | 7.11 | 7.54 | 7.53 | 7.57 | 0.91 |
| CoO | 0.67 | 0.67 | 0.65 | 0.64 | 0.64 | 0.63 | 0.63 | 0.63 | 0.62 | 0.62 | 0.61 | 0.59 | 0.59 | 0.67 | 0.59 | 0.63 | 0.63 | 0.63 | 0.08 |
| $MnO_2$ | 2.00 | 2.01 | 1.96 | 1.92 | 1.92 | 1.88 | 1.88 | 1.88 | 1.85 | 1.85 | 1.81 | 1.78 | 1.78 | 2.01 | 1.78 | 1.88 | 1.88 | 1.90 | 0.23 |

the heating curve of Fig. 1 and the temperature at which each second firing passed a reference point was noted. From these data it was possible to plot the expansion curve and to calculate the linear coefficient of thermal expansion of the enamel.

The cubical coefficient was obtained by tripling the linear coefficient. Allowance was made for the change of the index of refraction of the air with increasing temperature. Two sets each of three specimens of each enamel were run as checks.

The furnace was calibrated in two ways, (1) by inserting a standard thermocouple among the specimens, and (2) by running a platinum speci-

TABLE III

COEFFICIENTS OF EXPANSION TIMES $10^7$ IN VARIOUS TEMPERATURE RANGES

| Enamel | Temp. range | Coeff. $\times 10^7$ | Temp. range | Coeff. $\times 10^7$ | Temp. range | Coeff. $\times 10^7$ | Temp. range | Coeff. $\times 10^7$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 75–250 | 285 | 250–675 | 330 | 650–850 | 453 | 75–850 | 345 |
| 2 | 75–275 | 303 | 275–650 | 362 | 650–830 | 459 | 75–830 | 366 |
| 3 | 75–375 | 288 | 275–670 | 336 | 670–825 | 429 | 75–825 | 342 |
| 4 | 75–290 | 276 | 290–675 | 326 | 675–865 | 378 | 75–865 | 324 |
| 5 | 75–250 | 298 | 250–700 | 342 | 700–850 | 429 | 75–850 | 348 |
| 6 | 75–275 | 246 | 275–665 | 285 | 665–860 | 399 | 75–860 | 299 |
| 7 | 75–255 | 278 | 255–680 | 332 | 680–865 | 396 | 75–865 | 333 |
| 8 | 75–275 | 294 | 275–660 | 357 | 660–850 | 444 | 75–850 | 360 |
| 9 | 75–275 | 258 | 275–700 | 305 | 700–875 | 360 | 75–865 | 306 |
| 10 | 75–275 | 286 | 275–680 | 335 | 680–860 | 372 | 75–860 | 333 |
| 11 | 75–295 | 268 | 295–700 | 318 | 700–880 | 390 | 75–880 | 318 |
| 12 | 75–300 | 262 | 300–700 | 288 | 700–915 | 351 | 75–915 | 293 |
| 13 | 75–275 | 280 | 275–685 | 316 | 675–875 | 348 | 75–875 | 315 |

TABLE IV

ANNEALING AND SOFTENING TEMPERATURE OF THE ENAMELS

| Enamel | Annealing temp. (°F) | Softening temp. (°F) | Enamel | Annealing temp. (°F) | Softening temp. (°F) |
|---|---|---|---|---|---|
| 1 | 930 | 952 | 8 | 920 | 975 |
| 2 | 900 | 938 | 9 | 970 | 1003 |
| 3 | 940 | 952 | 10 | 960 | 990 |
| 4 | 970 | 976 | 11 | 965 | 1003 |
| 5 | 940 | 972 | 12 | 990 | 1042 |
| 6 | 990 | 1014 | 13 | 970 | 1010 |
| 7 | 960 | 984 | | | |

men and calculating the temperature from the known expansion of platinum which is accurately given in the International Critical Tables. The two methods of calibration gave the same correction values within 1%.

The coefficients of expansion, with the temperature ranges and the expansion calculated from the factors of Mayer and Havas, are given in Table III. The expansion curves of the enamels are shown in Figs. 2 to 9. The temperatures at which the enamels softened are an important index of fusibility and are tabulated in Table IV.

At first an attempt was made to check results without stirring the frits during melting and without remelting them. The result was a 15% variation in the expansion of different specimens of the same frit. Vigorous stirring of the molten frit with an iron rod reduced the variation to 5% but it was later deemed advisable to remove this source of contamination and remelt in platinum, which procedure reduced the variation.

Using simultaneous equations, the calculation of oxide factors was attempted, but the results were so variable that no average factor was calculated since it was apparent that no factor would satisfactorily represent the true expansion of the glass.

The effect of iron on the thermal expansion was determined by adding iron particles, which had been sifted through a No. 80 standard sieve, to the ground frit and thoroughly mixing before remelting and determining the expansion.

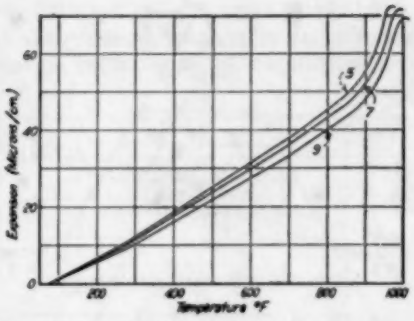


FIG. 2.—Effect of flint on thermal expansion. Enamels Nos. 5, 7, and 9.

**(1) Experimental Errors**

The possible experimental errors come from three sources: (1) errors in temperature measurement, (2) changes in chemical composition due to volatilization, and (3) variations in chemical composition due to the inhomogeneity of the glass.

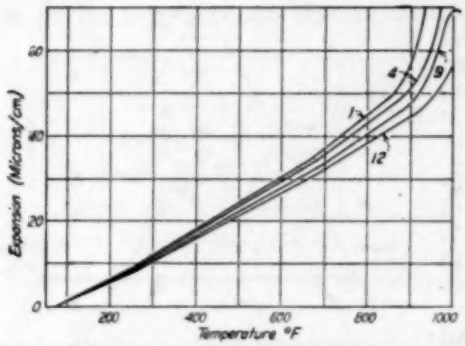


FIG. 3.—Effect of borax on thermal expansion. Enamels Nos. 1, 4, 9, and 12.

The error in temperature measurements, as shown by the check calibrations, was not over 1%. The losses due to volatilization are unknown but are probably small since the melting took place at a relatively low temperature. The inhomogeneity is indeterminate, but, since the expansion checked well, the glass was apparently quite homogeneous. The probable accuracy of the experiment is believed to be ±2%.

## IV. Experimental Results

The effect of additions of quartz to the batch on the thermal expansions of the enamels is shown in Fig. 2. The curves are those of enamels having successive differences of 6.7% in the quartz content. The borax to feldspar ratio is constant.

Figure 3 gives a graphical presentation of the effect of borax on the thermal expansion of the enamels. The feldspar to quartz

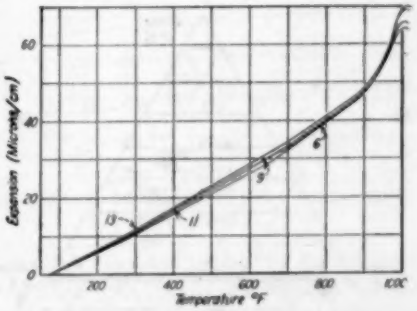


FIG. 4.—The effect of feldspar on thermal expansion. Enamels Nos. 6, 9, 11, and 13.

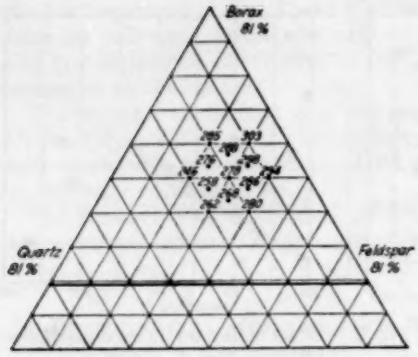


FIG. 5.—Coefficient of expansion × $10^7$; low-temperature range.

ratio is constant. The curves represent successive differences of 6.7% in the borax content.

Figure 4 depicts the variability in thermal expansion induced by changing the feldspar content of the batch. The borax to quartz ratio is constant. The curves are representative of enamels having successive differences of 6.7% in the feldspar content.

In Fig. 5, the coefficients of expansion in the low-temperature range are plotted on the triaxial diagram of compositions.

The average coefficients of expansion, not including the critical range through which the enamels show greatly increased rates of expansion, are plotted on the triaxial diagram of compositions in Fig. 6.

In Fig. 7 the softening temperatures of the enamels are plotted on a triaxial diagram of compositions.

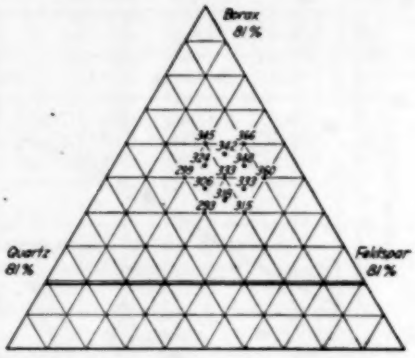


FIG. 6.—Average coefficient of expansion.

## V. Discussion of Results

A study of the average coefficients of expansion of enamels of groups (1) 2, 3, 4, and 6, (2) 5, 7, and 9, and (3) 8, 10, 11, and 12 reveals that in all cases an addition of quartz to the batch produced a decrease in the thermal expansion of the enamel. The average coefficient of expansion of the enamels is plotted against the per cent of quartz in Fig. 8. An increase of 6.7% in the quartz content produced an average decrease of 6.4% in the average coefficient of thermal expansion. The average difference is calculated only from the points on the line for enamels 5, 7, and 9, along which the feldspar to borax ratio remains constant. This average difference is slightly different from that calculated from all of the enamels. The straight lines may not represent the variations in expansion but they are as valid as any other type of curve since most of the variations from these lines are within the experimental error.

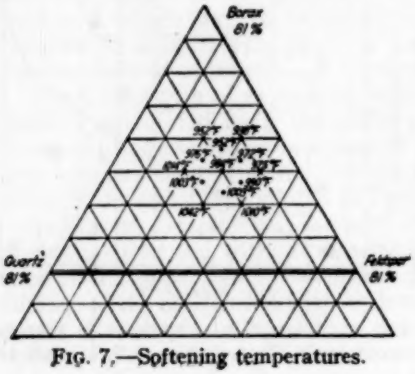


FIG. 7.—Softening temperatures.

Enamels of groups (1) 12, 9, 4, and 1, (2) 11, 7, and 3, and (3) 13, 10, 5, and 2 show that an increase in borax is always accompanied by an increase in the thermal expansion. The average coefficients of expansion are plotted against the per cent of borax in Fig. 9. Calculations based on the points along the line for enamels 11, 7, and 3, which has a constant feldspar to quartz ratio, show that an increase of 6.7% in the borax content of the batch induces an average increase of 5.5% in the average coefficient of expansion.

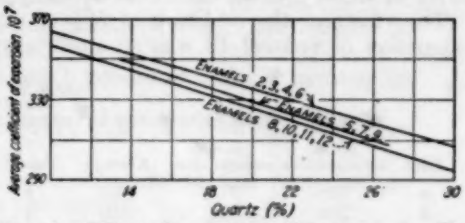


FIG. 8.—Effect of quartz on the average coefficient of expansion.

Enamels of groups (1) 1, 3, 5, and 8, (2) 4, 7, and 10, and (3) 6, 9, 11, and 13 show the effect of feldspar on the thermal expansion. The average coefficients of expansion are plotted against the per cent of feldspar in Fig. 10. Calculations from the points on the line for enamels 4, 7, and 10, which has a constant borax to quartz ratio, indicate that an increase of 6.7% in the feldspar content is productive of an average increase of 1.7% in the average coefficient of expansion.

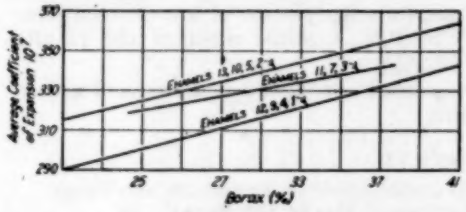


FIG. 9.—Effect of borax on the average coefficient of expansion.

The suitability of interpolated values can be checked by interpolation between two different pairs of coefficients for the same intermediate value. In Table V are shown the pairs of values obtained for points *a* to *l* by interpolating in different directions. The results for each point indicate that interpolation is satisfactory for determining the expansion of enamels in this field.

In Table VI the thermal expansion calculated from the oxide factors of Mayer and Havas[8] is compared with that actually observed during this investigation. The agreement is rather close in spite of the fact that these values are from the low-temperature range where the error is probably comparatively large. The expansion as calculated from the factors of other investigators was not in close agreement with the observed results, because probably the factors of Mayer and Havas were derived from enamel compositions while those of other investigators were derived from different types of glasses.

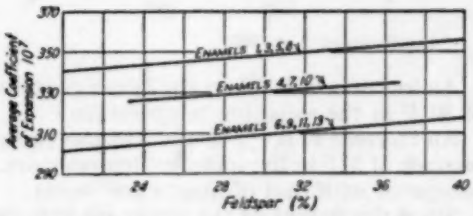


FIG. 10.—Effect of feldspar on the average coefficient of expansion.

[8] See footnote 2, p. 328.

The factors of Mayer and Havas do not indicate any difference in the slope of lines such as those in Fig. 9, and while they will give a very good approximation of the expansion of any given enamel, they assume a regularity of trend greater than that actually observed in this field.

The effect of the addition of 5% of metallic iron on the coefficient of expansion of enamel 13 was so small as to be practically imperceptible.

TABLE V

COMPARISON OF DIFFERENT INTERPOLATIONS FOR THE SAME POINT

| Point | First interpolation | Second interpolation | Average | Point | First interpolation | Second interpolation | Average |
|---|---|---|---|---|---|---|---|
| *a* | 316 | 315 | 316 | *g* | 328 | 324 | 326 |
| *b* | 339 | 333 | 336 | *h* | 338 | 336 | 337 |
| *c* | 350 | 345 | 347 | *i* | 340 | 338 | 339 |
| *d* | 347 | 341 | 344 | *j* | 333 | 333 | 333 |
| *e* | 324 | 325 | 325 | *k* | 324 | 320 | 322 |
| *f* | 312 | 313 | 313 | *l* | 321 | 320 | 321 |

The addition of iron changed the color of the enamel from a deep blue to a considerably lighter bluish green similar to that observed when an enamel is fired on sheet iron.

The softening temperature of an enamel is apparently a very definite and characteristic constant. The maximum deviation of a measured temperature from the average was 5°F (0.5%), while most of the results checked within 1°F (0.1%) or 2°F (0.2%).

An increase of 6.7% in the quartz content produced an average decrease of 25°F in the softening temperature.

TABLE VI

COMPARISON BETWEEN THE OBSERVED COEFFICIENTS OF EXPANSION AND THOSE CALCULATED FROM THE FACTORS OF MAYER AND HAVAS*

| Enamel | Observed | Calculated | Enamel | Observed | Calculated |
|---|---|---|---|---|---|
| 1 | 285 | 286 | 8 | 294 | 307 |
| 2 | 303 | 311 | 9 | 258 | 266 |
| 3 | 288 | 294 | 10 | 286 | 289 |
| 4 | 276 | 275 | 11 | 268 | 273 |
| 5 | 298 | 300 | 12 | 262 | 256 |
| 6 | 246 | 258 | 13 | 280 | 279 |
| 7 | 278 | 282 | | | |

* See footnote 2, p. 328.

An increase of 6.7% in the borax content produced an average decrease of 30°F in the softening temperature.

An increase of 6.7% in the feldspar content was followed by an average increase of 5°F in the softening temperature. The effect of feldspar is small compared with that of quartz and borax.

Since the weight of the upper interferometer plate was concentrated at three points, the softening probably took place under a considerable load.

## VI. Summary

(1) Interpolation between known values of expansion was satisfactory unless the compositions were quite different.

(2) The oxide factors of Mayer and Havas gave a fairly close approximation to the coefficients of expansion of sheet-iron ground-coat enamels.

(3) The calculated values indicated a more regular trend than was actually found in the field, especially in the case of additions of borax.

(4) The addition of quartz to the batch of an enamel produced a decided lowering of the coefficient of expansion.

(5) The addition of borax to the batch produced a decided increase in the coefficient of expansion of the enamel.

(6) The addition of feldspar to the batch produced a slight increase in the coefficient of expansion of the enamel.

(7) The solution of metallic iron had very little effect on the coefficient of expansion of the enamel.

(8) The use of the interferometer gave an accurate and reproducible value for the softening temperature of the enamel.

(9) An increase in the borax content of the batch produced a decided lowering of the softening temperature of the enamel.

(10) An increase in the quartz content of the batch produced a decided increase in the softening temperature of the enamel.

(11) Feldspar had little effect on the softening temperature of the enamel.

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# RELIABILITY OF CROSS-BEND, IMPACT, AND REFLECTIVITY DATA OBTAINED FROM VARIOUS SIZES OF TEST PIECES*

By G. H. McIntyre, J. T. Irwin, and M. G. Ammon

ABSTRACT

Cross-bend, impact, and reflectivity data are given on test pieces varying from 2 by 3 to 9 by 16 inches, using an application range of 30 to 100 grams per square foot (dry weight). The results indicate that the 4- by 12-inch test piece, properly prepared, may be used for such determinations with a minimum error.

## I. Introduction

Since the presentation of a Progress Report,[1] Shands, Türk, and Wolfram[2] have reported the effects of variations in kind and gage of metal stock, fineness of enamel, and firing temperatures on cross-bend, impact, and thermal-shock values.

The work reported previously by the writers has been thoroughly rechecked and the final results are given below. From an analysis of these results, the use of a 4- by 12-inch standard specimen for physical testing of enamels is recommended. The gage of metal and weight of application of the enamel will depend a good deal on the commercial application being checked or controlled. Perhaps, in line with the findings of Shands, Türk, and Wolfram,[2] it would be well for all laboratories experimenting with enamels to standardize on a 20-gage test sheet where the results are to be published or used for comparison with other published data. Where comparisons of cover-coat enamels are to be made at the same weights of application, 64 grams per square foot dry weight for two coats on one side are recommended as being the most practical.

This work was well under way at the time of the publication of the Shands, Türk, and Wolfram paper[2] and 18-gage metal was used.

## II. Experimental

A commercial enameling stock of 18-gage metal was used throughout. The sizes of test pieces used were 2 by 3 inches, 4 by 5 inches, 2 by 12 inches, 4 by 12 inches, and 9 by 16 inches.

After cleaning in a commercial metal cleaner, the metal was pickled in hot sulfuric acid (about 8%), washed, and neutralized, all under closely controlled, uniform conditions.

All test pieces were enameled in a commercial ground-coat enamel having a calculated cubical coefficient of expansion of $275 \times 10^{-7}$. The ground coat was applied at 38 grams per square foot two sides, fired weight. Firing temperature and time was 1580°F for 4¾ minutes.

A commercial white cover coat was applied at various apparent weights per square foot ranging from 30 to 120 grams per square foot. The mill additions for the white enamel were as follows:

| | |
|---|---|
| 100 lb. frit | 6 lb. tin oxide |
| 7 lb. dry powdered clay | 40 lb. water |

* Presented at the Annual Meeting, American Ceramic Society, Pittsburgh, Pa., February, 1933 (Enamel Division).

[1] Report presented at the Annual Meeting, American Ceramic Society, Washington, D. C., 1932 (Enamel Division).

[2] E. H. Shands, R. H. Türk, and H. G. Wolfram, "Factors Causing the Variation of Results in Tests for the Physical Properties of Enamels," *Jour. Amer. Ceram. Soc.*, **15**, 440 (1932).

Fineness: 5.9 grams residue on a 200-mesh sieve from a 50-cubic centimeter slip sample (specific gravity 1.82).

All samples were prepared from the same milling. The 4- by 12-inch strips were brushed so as to give two enamel strips for cross-bend, and the 9- by 16-inch sheets were brushed so as to give four enamel strips for cross-bend. The beads were brushed on all samples except the 2- by 3-inch and the 4- by 5-inch. Weight corrections were made to compensate for the loss in brushing. The firing temperature and time was 1500°F for $3^1/_2$ minutes. Seven test sheets of each size used were prepared at each of the following weights per square foot cover-coat application: 30, 60, 90, and 120 grams.

## III. Cross-Bend

The Lindemann-Danielson[3] cross-bend machine was used in these tests, increasing the arc one division or 0.02-inch per minute till failure occurred. Failure was recorded when a crack appeared across the entire width of each test strip of enamel. Although the Standards Committee[4] has recommended a 2-minute interval, extensive tests have indicated that the same results are obtained using a one-minute interval.

## IV. Impact

The number of blows at ten-second intervals required to shatter the cover-coat enamel through to the ground coat, using a one-inch diameter steel ball weighing 67 grams falling through 100 centimeters, was taken as failure.

## V. Reflectivity

A Taylor reflectometer,[5] with which the absolute reflection values of reflecting surfaces can be measured, was used in this work. The results are expressed in absolute units and represent the percentage reflection of light flux falling on the enamel surface. These results are therefore $^1/_2$ to 4% lower than would be obtained if the reflection as reported referred to magnesia as 100% reflection.

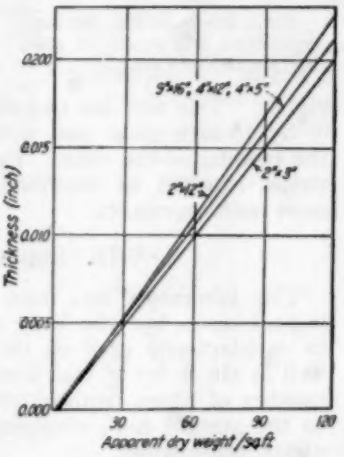


FIG. 1.—Relation between thickness and apparent weight per square foot.

## VI. Weight and Thickness of Coating

Good agreement of values for 4- by 5-inch, 4- by 12-inch, and 9- by 16-inch sheets was obtained. Narrow strips and small pieces as shown by the 2- by 12-inch and 2- by 3-inch test pieces, respectively, did not give reliable results.

The 2- by 3-inch pieces showed thinner coatings for equivalent weight

[3] R. R. Danielson and W. C. Lindemann, *Jour. Amer. Ceram. Soc.*, **8** [12], 795 (1925).

[4] "Tentative Method for Determination of Resistance of Sheet-Steel Enamels to Deflection," *Bull. Amer. Ceram. Soc.*, **9** [9], 270 (1930).

[5] U. S. Bur. Stand., *Sci. Paper*, No. 405.

measurements. This, it is believed in the light of reflectivity measurements, was due to a greater burning down of the enamel during the firing, *i.e.*, the coating was actually more dense. This effect was also slightly augmented by the slight beading of the enamel at the edges.

It is significant that the experimental points all lay very close to the straight-line curves for the larger pieces, and that there was correspondingly less agreement for the smaller pieces.

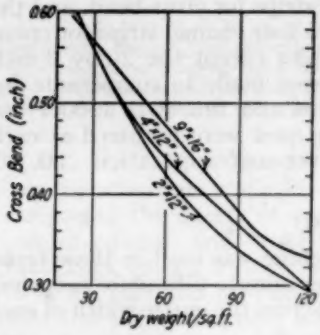


FIG. 2.—Relation between cross-bend and weight of coating per square foot.

## VII. Cross-Bend

As would be expected from the weight-thickness curves (Fig. 1), the cross-bend curves (Fig. 2) were lower for the 2- by 12-inch pieces than for the 4- by 12-inch and 9- by 16-inch. Other variables absent, the 4- by 12-inch and 9- by 16-inch pieces should give data in good agreement. Actually, the 9- by 16-inch data were the higher. This was due to a slight warpage which generally occurred in the 9- by 16-inch sheet and which was very difficult to compensate for in the reading of the data. The results obtained on the 4- by 12-inch test strips, brushed as described, have given the most uniform results.

## VIII. Impact

This laboratory has used several types of impact tests, but the only one which could be satisfactorily used on the 2- by 3-inch as well as the 9- by 16-inch tests was the average number of blows required to chip the enamel to the ground coat, dropping a 67-gram ball at 100 centimeters.

The curves (Fig. 3) show good agreement for all types of test pieces and are within the accuracy of this method of testing.

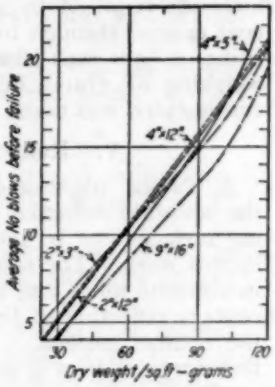


FIG. 3.—Relation between impact and weight of coating per square foot number of blows before failure (67-gram ball at 100 cm.).

## IX. Reflectivity

There was perfect agreement in the data obtained for the 4- by 5-inch, 9- by 16-inch, and 4- by 12-inch test pieces (Fig. 4). This is excellent confirmation of the results expected from the weight-thickness curves.

The agreement was also perfect between the 2- by 12-inch and 2- by 3-inch test pieces, but the reflectivity values were slightly higher for these sizes than for the other test pieces at weights above 40 grams per square foot. The high values for the 2- by 3-inch piece were probably due to the greater density of the enamel on the 2- by 3-inch piece (indicated by the weight-thickness curves) than on the larger pieces. There is no good

reason for the agreement between the 2- by 3-inch and 2- by 12-inch pieces. This illustrates the variability of results.

## X. Conclusions

(1) Apparent weight per square foot was directly proportional to the thickness. The ratio factor varied with size of test piece. Best agreement was obtained on pieces of relatively large area.

(2) No single determination gave accurate results. All data should be reported on not less than six samples.

(3) A 4- by 12-inch test piece, edges brushed back $^1/_8$ inch on each edge and a $^1/_8$- by 6-inch strip brushed down the center, is recommended for obtaining reliable cross-bend, impact, and reflectivity data on the same test piece, thus effecting a material and time savings in experimental and control work without sacrificing accuracy or reliability.

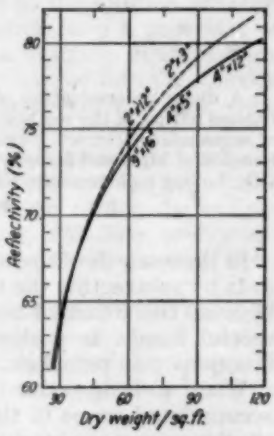


FIG. 4.—Relation between reflectivity and weight of coating per square foot.

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# A RAPID METHOD FOR THE ESTIMATION OF SODA IN GLASSES*

By S. R. Scholes

ABSTRACT

A direct determination of alkali is often avoided in glass analysis because of the tedious nature of the method and the estimation by difference is not justifiable because of accumulating errors. The method proposed consists in $HF-H_2SO_4$ decomposition, removal of MgO and $R_2O_3$ by lime, conversion of sulfate to carbonates by $Ba(OH)_2$ and $CO_2$, boiling to precipitate $CaCO_3$ and $BaCO_3$, and titration of $Na_2CO_3$.

## I. Introduction

In the analysis of the common soda-lime glasses, it is usual to estimate the soda by subtracting the total of the other oxides from 100%. This is done because the standard method of J. Lawrence Smith, accurate as it is in careful hands, is a slow process demanding much time and involving laborious manipulations.

When soda is taken by difference, the value accepted must bear the accumulated errors of the entire analysis, and there is no opportunity for checking accuracy by summation. It would be highly desirable, therefore, to have a means for estimating alkali more quickly and with fewer operations, so that actual determination may be more feasible and attractive.

## II. The New Method

The method here proposed is based upon the decomposition of the glass by hydrofluoric and sulfuric acids as done by Berzelius. Instead of conversion of sulfate to chloride by barium chloride, followed by the uncertain removal of barium, magnesium, and calcium by ammonium carbonate, a different procedure is offered.

One gram of the glass, crushed to pass an 80-mesh sieve, is weighed into a platinum dish or crucible, moistened with water, and covered with 20 milliliters of hydrofluoric acid, to which are added 30 drops of concentrated sulfuric acid. This quantity of sulfuric acid insures the complete removal of hydrofluoric acid and absence of fluorides in the product of the evaporation.

The first stage of the evaporation is best performed on a water bath. When the syrupy stage is reached, the dish is heated on a hot plate until the sulfuric acid is practically fumed away, and the residue sets as a stiff mass upon cooling. The mixed sulfates and sulfuric acid are now removed from the dish to a 250-milliliter beaker, using rinsings of water to a total of about 50 milliliters.

A few drops of phenolphthalein indicator are added, and pure CaO (prepared by ignition of reagent $CaCO_3$) with thorough stirring until a pink color appears, then a few tenths of a gram in excess. Bringing the solution to a boil completes the precipitation of magnesium, iron, and aluminum as hydrates.[1]

Filtration, followed by washing with hot water until the precipitate shows no remaining pink color, carries into the filtrate sodium sulfate, together with the sparingly soluble sulfate and hydroxide of calcium.

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* Presented at the Annual Meeting, American Ceramic Society, Pittsburgh, Pa., February, 1933 (Glass Division).

[1] J. C. Hostetter, *Ind. Eng. Chem.*, **6**, 392 (1914).

Barium hydroxide, in excess of that necessary to react with the sulfates (about $2^1/_2$ grams of the solid hydrate), is added to the solution which is stirred to effect complete reaction. Carbon dioxide from a generator or storage cylinder, passed through a wash-bottle containing dilute sodium carbonate to intercept any possible acid spray, is bubbled into the solution through a small glass nozzle until the disappearance of the pink color assures that all the bases have been completely carbonated.

The solution is boiled for about five minutes to remove free carbonic acid and precipitate calcium and barium as carbonates. The pink color of the phenolphthalein has now returned. Filtration brings the sodium carbonate solution into a titration flask. Washing with four or five applications of hot water, or until the indicator color is entirely removed from the sulfate-carbonate precipitate, is sufficient.

The sodium carbonate solution is now to be titrated with standard hydrochloric acid, using an indicator such as brom-phenol blue or methyl orange. Fifth-normal acid, of which 25 to 30 milliliters will be required for the ordinary bottle glass and which gives a sharp end-point, will be found satisfactory.

## III. Value of the Method

This method is especially adapted to soda determination. If potash is also present, the chloride solution may be evaporated, the salt weighed, and potash separated in the usual manner.

The entire process, up to the titration, can be carried out in four to five hours. For student work, it has yielded satisfactory results on standard samples of soda-lime glasses.

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# IMPORTANT ANNOUNCEMENT

Beginning with this month *The Bulletin of the American Ceramic Society*, carrying the advertisements, will be issued under its own cover. The issue date will be the 15th day of each month.

◆ ◆

The *Journal of the American Ceramic Society* and *Ceramic Abstracts*, each with its own pagination, will continue to appear under one cover. The issue date will be the first of each month (as usual).

◆ ◆

*The Bulletin* will be sent to members on account of membership dues paid. To non-members, the annual subscription price for the *Bulletin* will be $1.50 domestic and $2.00 foreign.

◆ ◆

The scope of *The Bulletin* will be confined to promotion of ceramic education and technology.

# CERAMIC ABSTRACTS

**Compiled by the**

## AMERICAN CERAMIC SOCIETY

Ross C. PURDY, Editor

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## Abrasives

**Aluminum oxide *vs.* garnet as a wood abrasive.** J. F. TRAENDLY. *Wood Industry*, Vol. 54, No. 13 (1932); abstracted in *Mech. Eng.*, **54** [11], 800 (1932).—A table is given covering time-study tests of belts used in a woodworking plant with the labor and material costs involved. F.G.H.

**Correct abrasive terminology.** HENRY R. POWER. *Metal Cleaning & Finishing*, **5** [4], 169–70 (1933).—Definitions which assist in the correct use of abrasive terms are given. The misuse of the word "emery" for all sorts of abrasives, including Aloxite and Carborundum, is explained and corrections are made. E.J.V.

**Automatic internal grinder.** H. L. BLOOD. *Machine Shop Practice*, Vol. 54, No. 1 (1932); abstracted in *Mech. Eng.*, **54** [7], 511 (1932).—B. describes an automatic internal grinding machine which positively determines the size of the hole and which requires no gaging. The machine and its adaptation for special grinding jobs are described. F.G.H.

**Rotor of grinder is magnesium casting.** MADISON-KIPP CORP. *Foundry*, **61** [2], 66 (1933).—Illustrated. F.G.H.

**Good surfaces.** H. RAGOTZI. *Werkstattstechnik*, **26** [16], 315–18 (1932); abstracted in *Mech. Eng.*, **55** [1], 71–72 (1933).—The comparison and testing of finishes obtained by diamond cutting, lapping, and grinding with various grit sizes are described. F.G.H.

**Observations and scientific knowledge of modern working processes and their media and treatment for the entire glass industry.** J. F. KESPER. *Diamant*, **54** [33], 446–47 (1932).—K. discusses centerless grinding, various types of polishing and cutting media other than diamonds, and the proper handling of celluloid in preparing to make safety glass with it as the intermediate layer. E.J.V.

### PATENTS

**Grinding machinery.** R. N. HEALD AND E. M. TAYLOR (Heald Machine Co.). U. S. 1,903,562, April 11, 1933. E. C. HEAD (Gleason Works). U. S. 1,903,967, April 18, 1933. F. S. HAAS (Heald Machine Co.). U. S. 1,904,045, April 18, 1933. H. L. CROWLEY (Henry L. Crowley & Co., Inc.). U. S. 1,904,274, April 18, 1933. C. G. HUNT (Cincinnati Grinders, Inc.). U. S. 1,904,642, April 18, 1933. F. S. HAAS AND CLEMENT BOOTH (Cincinnati Grinders, Inc.). U. S. 1,905,224, April 25, 1933. F. J. JESCHKE (Micromatic Hone Corp.). U. S. 1,908,252, May 9, 1933.

**Mechanism for reciprocating grinding wheel spindles.** W. J. GUILD (Heald Machine Co.). U. S. 1,904,044, April 18, 1933.

**Polishing apparatus, specially for knives, forks, and spoons.** ROBERT ERN. U. S. 1,904,282, April 18, 1933.

**Method and machine for grinding chasers.** R. E. FLANDERS (Jones & Lamson Machine Co.). U. S. 1,904,304, April 18, 1933.

**Honing device.** JOSEPH SUNNEN. U. S. 1,904,336, April 18, 1933.

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[1] The abbreviation (*C.A.*) at the end of an abstract indicates that it was obtained from *Chemical Abstracts* by coöperative agreement.

The bold-face number following the journal name is the volume, the issue number is in brackets followed by the page numbers, then the year in parentheses.

**Grinding and polishing attachment for rolling mills.** H. A. POLING (F. S. Symmonds). U. S. 1,904,385, April 18, 1933.

**Improved abrasive coated material.** H. N. MORRIS (Rucel, Ltd.). U. S. 1,904,663, April 18, 1933. An abrasive coated material comprises a backing sheet and a powdered abrasive material secured thereto by a homogeneous film containing rubber and cellulose in intimate association, at the same time attaching the abrasive, and filling and waterproofing the backing sheet.

**Hydraulically operated grinding machine.** A. G. BELDEN AND H. A. SILVEN (Norton Co.). U. S. 1,905,127, April 25, 1933.

**Safety device for grinders.** C. T. RAULE. U. S. 1,905,651, April 25, 1933.

**Valve grinder.** ADOLPH WERNER. U. S. 1,906,350, May 2, 1933. G. A. FULLIPS. U. S. 1,906,745, May 2, 1933.

**Abrading machine.** G. D. ALDERMAN (United Shoe Machinery Corp.). U. S. 1,906,503, May 2, 1933.

**Holder for use in grinding machines.** JACOB SCHICK (Magazine Repeating Razor Co.). U. S. 1,906,635, May 2, 1933.

**Abrading machine and method of grinding.** WILLIAM WUERFEL (Wilkening Mfg. Co.). U. S. 1,906,731, May 2, 1933.

**Abrasive body and method of manufacture.** E. E. NOVOTNY (John Stogdell Stokes). U. S. 1,907,088, May 2, 1933.

**Blade grinding machine.** JACOB SCHICK AND DORILAS NADEAU (Magazine Repeating Razor Co.). U. S. 1,907,446, May 9, 1933.

**Combined grinder and comparator.** ROBERT THOMSON (Dardelet Thread-Lock Corp.). U. S. 1,907,469, May 9, 1933.

**Sharpener for slicing machine knives.** B. G. ROETERING (U. S. Slicing Machine Co.). U. S. 1,907,585, May 9, 1933.

**Finish honing machine for razor blades.** T. C. SHEEHAN (Wade & Butcher Corp.). U. S. 1,907,595, May 9, 1933.

**Grinding, polishing, or buffing machine.** C. B. LARSON (W. C. Hammond). U. S. 1,908,029, May 9, 1933.

**Lapping machine.** SYDNEY PLAYER AND H. S. INDGE (Norton Co.). U. S. 1,908,048, May 9, 1933.

**Grinding fixture for thread cutting tool bits.** JOHN JORGENSEN. U. S. 1,908,155, May 9, 1933.

**Abrasive stone holder.** G. M. CALVERT (Micromatic Hone Corp.). U. S. 1,908,218, May 9, 1933.

**Safety blade sharpener.** L. B. CUDDY (Kinley J. Tener). U. S. 1,908,223, May 9, 1933.

**Table mounting for grinding machines.** CARROLL KNOWLES (Pratt & Whitney Co.). U. S. 1,908,259, May 9, 1933.

**Abrasive cover.** E. F. HODGKINS (U. S. Machinery Corp.). U. S. 1,908,355, May 9, 1933.

**Machine for sharpening gear cutters.** S. H. EARL (Gleason Works). U. S. 1,908,476, May 9, 1933.

**Oscillating grinder.** C. E. VAN NORMAN (Van Norman Machine Tool Co.). U. S. 1,908,577, May 9, 1933.

**Method of constructing pneumatic drills, grinding machines, etc.** J. HAMMERSLEY. Brit. 389,586, March 29, 1933.

**Manufacture of lapping wheels, hones, or other tools having an abrasive operating face.** A. C. WICKMAN, LTD., AND A. C. WICKMAN. Brit. 390,609, April 20, 1933.

**Cylinder honing devices.** W. W. TRIGGS. Brit. 390,622, April 20, 1933.

**Tools for turning or truing grinding wheels or disks.** F. WERNER AKT.-GES. Brit. 389,762, March 29, 1933.

**Machine for grinding the threads of screw-cutting taps and the cutting edges and adjacent parts of other cutters.** H. F. ATKINS. Brit. 390,954, April 26, 1933.

**Machines for dressing grinding wheels.** H. F. ATKINS. Brit. 390,991, April 26, 1933.

## Art and Archeology

**Pink glazes.** J. KLUG. *Keram. Rund.*, **40**, 635 (1932).—The preparation of pink glazes falls into two distinct operations: the preparation of the actual pink color and the preparation of the red glaze. The true chemical constitution of the pink color has not yet been defined; in all probability it is due to a modification of chromium oxide, the color of which is affected considerably by the presence of calcium oxide, quartz, and

boric acid. The shade of color is not altered by increasing the potassium bichromate in the well-known recipe for pinks; this can only be done by varying the quantities of the three components, quartz, calcite, and boric acid, and by increasing the tin oxide content. The color is prepared as follows: (*a*) tin oxide, ground calcite, and ground quartz are finely ground together and allowed to settle, the superfluous water is drawn off, and the mixture dried to paste consistency; (*b*) potassium bichromate and borax are dissolved in as little hot water as possible and then mixed with the paste (*a*) in small amounts at a time. The mixture is then slowly dried and ground and thoroughly mixed in a porcelain mortar. When quite dry the light yellow powder is spread thinly over clean biscuit plates and fired in a strongly oxidizing oven to cone 8 to 10. It is advisable to admit a fireproof tube, open to the atmosphere, into the muffle. The fired product is finely ground, thoroughly washed with warm water, dried, fired again to cone 8 to 10, and finely ground and washed again. A mixture of 4 parts tin oxide, 4 parts ground quartz, and 2 parts powdered calcite, ground together and fired to cone 8 to 10, may be used as a diluent. A number of examples is given. (*T.C.S.E.*)

**Design and form as applied to the manufacture of glassware.** ANON. *Glass*, **10** [3], 109–10 (1933).—A discussion is presented of a paper by J. H. Hogan read before the Royal Society of Arts (see *Ceram. Abs.*, **12** [5], 187 (1933)). G.R.S.

**Why Sweden leads in design.** ANNA HONG RUTT. *Amer. Mag. Art*, **26** [4], 169–80 (1933).—Sweden, an acknowledged leader in design among the nations, trained the taste of the people to appreciate the two distinct craft movements, (1) reproduction of old handicrafts, and (2) creation of modern art suitable for machine production. The article includes illustrations of glassware. E.B.H.

**Beauty master.** ANON. *Brick Clay Rec.*, **82** [4], 130–31 (1933).—Interesting brickwork used in new buildings is illustrated. E.J.V.

**Bench show.** ANON. *Arts & Dec.*, **38** [6], 34–35 (1933).—Glass and porcelain sculptured dogs are shown. E.B.H.

**Spode bicentenary.** W. B. H. *Connoisseur*, **91** [380], 269 (1933).—H. traces the history of Josiah Spode and announces the coming celebration of his bicentenary at Stokes which will include the roasting of an ox and the making of a piece of porcelain from its calcined bones in commemoration of his addition of this ingredient to the English porcelain of that day, producing a ware competing with Continental porcelains. E.B.H.

**Site of the Chelsea Porcelain Factory.** BELLAMY GARDNER. *Connoisseur*, **91** [379], 170–73 (1933).—During the proprietorship of Nicholas Sprimont, in the early 18th Century, part of a tenement house on Lawrence Street in Chelsea was occupied by the Chelsea Porcelain Manufactory, and a print of the building is now in the Chelsea Public Library as is also a print of the Cross Keys alehouse where this porcelain was once for sale. Three figures of Chelsea birds are illustrated reprinted from Old English Porcelain in the Lady Ludlow Collection (*Ceram. Abs.*, **12** [5], 180 (1933)). E.B.H.

**Old English glasses. No. 40. Drinking glasses with candlestick stems.** F. BUCKLEY. *Glass*, **10** [3], 107–108 (1933).—Glassmakers elaborated the simpler baluster-stem drinking glasses and the introduction of glass candlesticks at the end of the 17th Century gave practice in the production of complicated stem forms. Seven illustrations. For No. 39 see *Ceram. Abs.*, **12** [5], 188 (1933). G.R.S.

**Two Ravenscroft sealed goblets.** ANON. *Connoisseur*, **91** [379], 200 (1933).—Two Ravenscroft sealed goblets, about 1673–1681, are the only intact examples of their kind known to be in existence; they recall the history of George Ravenscroft, the first English glassmaker to produce glass vessels of every description in London. In 1676, the glass perfected, he agreed that a raven's head should be set in all his ware. See also abstract by J. McCormack, *Ceram. Abs.*, **12** [2], 58 (1933). E.B.H.

**Gilders' marks on Derby china.** WILLIAM H. TAPP. *Connoisseur*, **91** [380], 234–40 (1933).—T. discusses gilders' marks and illustrates pieces and marks. E.B.H.

**Stained glass in the Metropolitan Museum, New York.** ELIZABETH LUTHES CARY. *Stained Glass*, **27** [12], 338–40 (1932). M.V.K.

**Great west window at Wells.** J. ARMITAGE ROBINSON. *Jour. Brit. Soc. Master Glass Painters*, **4** [3], 109–23 (1932).—A detailed description of the famous window of the Wells cathedral is given. Illustrated. M.V.K.

**Old stained glass in Oxfordshire.** EDMUND SPENCER BOUCHER. *Jour. Brit. Soc. Master Glass Painters*, **4** [3], 123–33 (1932).—Ancient glass found in Oxfordshire is described. M.V.K.

**Medieval glass in Elsing church, Norfolk.** CHRISTOPHER WOODFORDE. *Jour. Brit. Soc. Master Glass Painters*, **4** [3], 134–36 (1932).—An account of the ancient glass found in the Elsing church is given. M.V.K.

**Some heraldic glass in Norwich.** ERNEST A. KENT. *Jour. Brit. Soc. Master Glass Painters*, **4** [3], 137–41 (1932).—Windows of the 18th Century summerhouse at Lakenham Grove, Norwich, containing the arms of the Duke of Norfolk, the badge of Edward Prince of Wales, and arms of King Henry VIII, are described. Illustrated. M.V.K.

**Crucifixion window at Poitiers.** ABBÉ AUBER. *Stained Glass*, **27** [12], 334–37 (1932).—The famous window of the cathedral of Poitiers, France, is described in detail. The window dates from the end of the 12th Century and is considered to be one of the oldest examples of glass painting of that period. M.V.K.

**A Leipzig tile kiln of the Gothic period.** ALBERT SCHRODER. *Sprechsaal*, **66** [8], 129–30 (1933).—Illustrations of a number of decorative tile are given showing the work of an unknown Leipzig artisan of the 15th Century. W.W.B.

**Department of Classical Art: extension and rearrangement.** G. M. A. RICHTER. *Bull. Met. Mus. Art*, **28** [2], 28–33 (1933).—A gallery at the south end of the Roman Court has been recently given over to Etruscan and Italic antiquities. The black bucchero vases, terra cotta heads and figures, and the imported Athenian black-figured and early red-figured vases found in Etruscan tombs help to tell the story of the Etruscans who left no written history or literature behind them. A.A.A.

**New light on the art of prehistoric Persia.** A. U. POPE. *Illus. London News*, **182**, 116–19 (1933).—Further discoveries at Damghan range in date from 4000 to 1600 B.C. The pottery has animal designs, *e.g.*, leopard, ibex, etc. 22 photographs. See also *Ceram. Abs.*, **12** [3], 92 (1933). H.H.S.

**Mycenean pottery at Ras Shamra.** F. A. C. SCHAEFFER. *Illus. London News*, **182**, 177–81 (1933).—The fourth season's work of the French Mission at Ras Shamra in Syria is described with 20 photographs. See also *Ceram. Abs.*, **11** [4], 224 (1932). H.H.S.

## BOOKS

**Excavation of Tell Bett Mirsim. Vol. I. Pottery of the First Three Campaigns.** H. J. CADBURY. xxi + 94 pp. 71 plates. Yale Univ. Press, New Haven, 1932. Price $6.00. Reviewed in *Times Lit. Supp.*, **32**, 60 (1933). H.H.S.

**Excavations at Eutresis in Bœotia.** HETTY GOLDMAN. Harvard Univ. Press, 1932. Price $20.00. Reviewed in *Times Lit. Supp.*, **32**, 125 (1933). H.H.S.

## PATENTS

**Design for sherbet glass.** R. C. DIEBENKORN (Dohrmann Hotel Supply Co.). U. S. 89,613, April 18, 1933.

**Design for tumbler.** R. C. DIEBENKORN (Dohrmann Hotel Supply Co.). U. S. 89,614, April 18, 1933. F. S. BARBIERS (Hocking Glass Co.). U. S. 89,845, May 9, 1933.

**Design for jar.** IVOR CORDY (Hazel-Atlas Glass Co.). U. S. 89,630, April 18, 1933.

**Design for bottle.** E. H. FABRICE. U. S. 89,632, April 18, 1933. W. A. NESTER (Obear Nester Co.). U. S. 89,786, May 2, 1933.

**Design for combined glass container and cover.** A. C. CRIMMEL AND H. H. CRIMMEL. U. S. 89,681, April 25, 1933.

**Design for goblet.** D. E. MARTIN (U. S. Glass Co.). U. S. 89,713 and 89,714, April 25, 1933. J. C. KELLY. U. S. 89,769, May 2, 1933. W. L. ORME. U. S. 89,821, May 9, 1933.

**Design for glass container.** A. D. NASH (Libbey Glass Mfg. Co.). U. S. 89,716, April 25, 1933.

**Design for plate.** A. R. APPLE (Wallace China Co.). U. S. 89,735, May 2, 1933. E. L. SCHNEPF (Scammell China Co.). U. S. 89,860, May 9, 1933.

**Design for cabinet range, etc.** A. G. SHERMAN. U. S. 89,798, May 2, 1933.

**Design for beverage cooler.** J. H. READIO, JR. (Liberty Refrigeration Corp.). U. S. 89,819, May 9, 1933.

**Design for urn.** W. L. ORME. U. S. 89,820, May 9, 1933.

**Design for jug.** J. C. KELLY. U. S. 89,828, May 9, 1933.

**Design for lighting fixture globe.** G. B. METZ (Gleason-Tiebout Glass Co.). U. S. 89,851, May 9, 1933.

**Electrodeposition of tin-gold alloys.** H. J. KERSTAN (Board of Directors, Univ. of Cincinnati). U. S. 1,905,105, April 25, 1933. An electrolyte for producing white gold deposits has substantially the following proportions: gold potassium cyanide ($KAu(CN)_2$) 3 g., potassium stannate $K_2SnO_3$ : $H_2O$ 10 g., water 1 liter.

**Electrodeposition of zinc-gold alloys.** H. J. KERSTAN (Board of Directors, Univ. of Cincinnati). U. S. 1,905,106, April 25, 1933. An electrodeposit of gold and zinc has a

lilac color and comprises approximately 30% of zinc to 70% of gold, the electrodeposit being dense and homogeneous and not subject to attack by concentrated and dilute nitric acid.

**Decalcomania transfer.** J. B. LAWRENCE (American Decalcomania Co.). U. S. 1,906,909, May 2, 1933. A. H. STEVENS (W. B. Kerr Corp.). Brit. 390,832, April 26, 1933.

## Cements

**Application of Rankin's equilibrium diagram of the system, $CaO$–$SiO_2$–$Al_2O_3$, to the practice of cement clinkering.** SERBAN SOLACOLU. *Zement*, **22** [2], 17–22; [3], 33–38 (1933).—Numerous mixtures in the system, $CaO$–$SiO_2$–$Al_2O_3$, with constant $Fe_2O_3$ content are examined and the values expressed in a four-coördinate system. Cements in 9 groups of the same silicate modulus are varied as to their lime saturation values within each group. The resultant strength values showed 3 major divisions, *viz.*, the usual Portland cements high in silica, aluminous cements of the accepted characteristics, and a new group of aluminous cements of high initial strength but excellent later values. These cements contain up to 60% alumina with little or no silica and require high clinkering temperatures. M.V.K.

**Course of reaction when firing cement in the system, $CaO$–$SiO_2$–$Al_2O_3$(–$Fe_2O_3$).** SERBAN SOLACOLU. *Zement*, **22** [15], 191–95 (1933).—In all cements of the system, $CaO$–$SiO_2$–$Al_2O_3$(–$Fe_2O_3$), the decomposition of silica by lime depends on the height of the sintering or melting temperature. It has been found in practice in cement firing that tricalcium silicate appears only in systems whose silicate modulus is over 0.3. Iron oxide, which has been analytically determined only as dicalcium ferrite in alumina cements of accepted characteristics and in siliceous cements, is present in alumina cements of the new group partly as monocalcium ferrite. In all cements, the beginning dissociation of iron oxide is marked by the appearance of gas bubbles. In fused Portland cement, a small content of free lime and uncombined silica shows, in comparison with the corresponding sintered cements, that the course of reaction has been approaching the limit of the combining of lime. The strength of fused cement, however, is lower than that of the sintered. M.V.K.

**Action of hydrate of lime on the hydration of fused aluminous cement. I.** K. KOYANAGI. *Zement*, **22** [10], 129–34 (1933); for abstract see *Ceram. Abs.*, **12** [4], 142 (1933). M.V.K.

**Effect of mixing Portland and aluminous cements.** K. E. DORSCH. *Concrete Constr. Eng.*, **28** [2], 151–54 (1933).—Results show aluminous cement to be unsuitable for use as a protective coating to prevent the attack of Portland cement concrete by salt solutions. Illustrated with photomicrographs. F.G.H.

**Lime limits of Portland cement.** EBERHARD SPOHN. *Zement*, **21** [50], 702–706; [51], 717–23; [52], 731–36 (1932).—The highest amounts of $CaO$ capable of combination with $SiO_2$, $Al_2O_3$, and $Fe_2O_3$ were determined. The saturation value in practice indicates the composition for cement to be $3CaO{\cdot}SiO_2$–$2CaO{\cdot}Al_2O_3$ or $3CaO{\cdot}Al_2O_3$ in cements higher in alumina. At least 1455° must be reached to insure complete clinkering. When alumina and iron oxide are present in equivalent amounts, the lime saturation value indicates a composition $3CaO{\cdot}SiO_2$–$4CaO{\cdot}Al_2O_3{\cdot}Fe_2O_3$. A monographic method for calculating the highest possible lime content in Portland cement is suggested. M.V.K.

**Recast analysis and its relation to the chemistry of Portland cement. IX. Computation of Portland cement raw mixtures (continued).** LOUIS A. DAHL. *Rock Prod.*, **36** [3], 32–33 (1933).—D. continues with examples of computations of cement mixtures from the recast analysis using algebraic formulas and charts. For Part VIII see *Ceram. Abs.*, **12** [5], 180 (1933). W.W.M.

**Low-heat cement for mass concrete.** R. W. CARLSON. *Eng. News-Rec.*, **109** [16], 461–63 (1932); abstracted in *Mech. Eng.*, **54** [12], 863 (1932).—The present trend in mass-concrete cement is toward less tricalcium silicate, more dicalcium silicate, and a minimum percentage of the troublesome tricalcium aluminate. F.G.H.

**Asbestos-cement products.** E. G. SMITH. *Times Eng. Supp.*, **31**, VII (Feb. 25, 1933).—Formerly regarded with derision, asbestos-cement products are now used in enormous quantities for roofing, ceilings, partitioning, paneling, and lining of interior and exterior walls. Rain-water pipes, guttering, and fittings are waterproof, require no painting, and are claimed to be stronger than cast iron. H.H.S.

PATENTS

**Process of manufacturing white Portland cement, etc.** GUSTAV BERGEN, FELIX ENGELHARDT, AND RICHARD STECKHAN ("Miag" Mühlenbau und Industrie A.-G.). U. S. 18,805, April 25, 1933 (reissue). The process of manufacturing cement consists in adding fluorspar and borax to ground raw material containing coloring matter, melting the mixture, granulating it, and thereafter treating it for transforming it into cement.

**Hydraulic cement mortar and method of compounding.** F. C. LANGENBERG, H. S. HUNT, AND H. G. REDDICK (U. S. Pipe and Foundry Co.). U. S. 1,908,637, May 9, 1933. The method of compounding a hydraulic cement mortar substantially free from uncombined lime consists in mixing with the ingredients during the compounding of the mortar a substance rich in monocalcium silicate and in addition uncombined oxalic acid dissolved in the water used in compounding the mortar.

## Enamels

**Mechanics of enamel adherence. VIII.** R. M. KING. *Jour. Amer. Ceram. Soc.*, **16** [5], 232–38 (1933); for Parts IV to VII see *Ceram. Abs.*, **11** [10], 516 (1932).

**Reboiling of enamels and tests for adherence. III.** ANSON HAYES. *Better Enameling*, **4** [3], 13–14 (1933).—H. gives the requisites for good adherence of enamel to base metal. He discusses tests for measuring adherence and analyzes impact test results. Although fishscaling does not occur in every case of a poor bond, it has not been observed where there is a good bond. Reboiling is the formation of bubbles which often occurs in the ground coat enameling during the second firing when conducted at 1500 to 1600°F. Observations indicate that the reboiling is associated with conditions which form stresses in enamel coats. For Part II see *Ceram. Abs.*, **12** [5], 181 (1933). W.W.M.

**Blistering of cast-iron enamel. Progress Report. II.** E. P. POSTE. *Jour. Amer. Ceram. Soc.*, **16** [6], 277–92 (1933); for Progress Report I see *Ceram. Abs.*, **11** [10], 516 (1932).

**Influence of the Si-content of gray cast iron on bubble formation in wet enamel.** O. KEMPE. *Keram. Rund.*, **40**, 469 (1932).—It is shown that as the silicon contents of cast iron increase, the tendency to bubble formation diminishes. It is recommended that an iron be used with a silicon content of about 2.5 to 2.7%, a phosphorus content of above 1%, and a manganese content of less than 0.6%. With a good homogeneous enamel the quantity of gas released is so small that it can not break through. (*J.S.G.T.*)

**Use of fluorides in enamels.** R. M. KING. *Ceram. Ind.*, **20** [4], 194–96 (1933).—Fluorides are used in enamels for opacifying and fluxing. K. gives other effects of fluorides in enamels. The effects of cryolite and fluorspar and their use in enamels were investigated and observations from this survey are given. The effects of increasing amounts of potassium nitrate and sodium carbonate were also studied. Possible development of enamels of low maturing temperatures was investigated, working from a fluoride eutectic basis. The results of this work on sheet steel ground coats were negative but two cover-coat enamels maturing 150°F lower were developed. Cast-iron enamels showed no difference between eutectic enamels and the original. In no case did the acid test indicate any difference in the resistance of any enamel. W.W.M.

**Beryllium as a raw material for enamels.** VIELHABER. *Emailwaren-Ind.*, **10** [12], 95–97 (1933).—A number of experimental enamels containing beryllium is described. The beryllium lowers the melting temperature of the enamels considerably. W.W.B.

**Influence of less common elements when added to cast iron.** J. E. HURST. *Foundry Trade Jour.*, **48**, 137–39 (1933).—The influence of Be, B, Na and K, Mg, Ca, Zn, Se, As, Zr, Sn, Sb, Ce, Pb, and Bi is described. H.H.S.

**Newer methods of metal cleaning.** C. J. S. WARRINGTON. *Can. Chem. Met.*, **17** [4], 77–78 (1933).—Research in the general principles of detergent action has been applied to the production of balanced cleaning powders having the necessary wetting, emulsifying, deflocculating, anti-corrosive, and buffered alkalinity range for particular classes of grease removal and types of metal. Development of chlorinated hydrocarbons such as trichlorethylene and the addition of stabilizing agents permit their use in liquid and vapor phase degreasing plants incorporating continuous recovery systems. The method is suitable for uninterrupted production cycles. The introduction of

pickling inhibitors improves the efficiency, economy, and comfort of pickling operations for scale and oxide removal by acids. The use of acid for grease removal is inefficient. E.J.V.

**Theory of chemical cleaning of enamelware.** A. I. ANDREWS. *Ceram. Ind.*, **20** [4], 178 (1933).—Chemical cleaners are akaline solutions containing colloidal material. They depend upon the phenomena of saponification and emulsification for their action. A. defines the terms "saponification" and "emulsification" and discusses what happens in cleaner solutions. The chemistry and $p_H$ value of cleaning solutions and the action of buffer salts are considered. Electrolytic cleaning is described in detail. This method is much more rapid than still cleaning and is becoming more common, especially where continuous automatic cleaning equipment is used. W.W.M.

**Control of the pickling solution.** H. KARMAUS. *Emailwaren-Ind.*, **10** [4], 27–28 (1933).—The importance of the proper control of pickling operations in enameling is discussed and several precautions are suggested. W.W.B.

**Control of hardness and other mold properties.** H. W. DIETERT. *Trans. Amer. Foundrymen's Assn.*, **3** [4], 63–70 (1932); abstracted in *Mech. Eng.*, **54** [11], 815 (1932).—The control of sand conditions and the physical properties of sand in rammed molds are described. The effect of sand grain sizes on permeability and mold hardness is discussed. F.G.H.

**Control features steel foundry.** F. G. STEINEBACH. *Foundry*, **61** [2], 20–61 (1933).—The microscopic examination of the shape and size of sand grains for various types of molds is discussed. Mechanical methods of sand handling are also described. Illustrated. F.G.H.

**Copper and Brass Research Assn. announces new enamel.** ANON. *Enamelist*, **10** [5], 11 (1933).—An enamel for copper and certain copper alloys has been developed at Battelle Memorial Institute, Columbus, Ohio, by the Copper and Brass Research Assn. The product, called "Crystal-cote," has successfully withstood the shock of a temperature range of 1700°F to −58°F. By manipulation of the process of application a wide range of colors can be obtained. The coating is thin, transparent, and flexible. Ferro Enamel Corp. will manufacture and sell the frits. A wide variety of uses is possible. W.W.M.

**Review of enamel with respect to its constitution and testing methods. I.** H. I. KARMAUS. *Sprechsaal*, **65** [51], 907–908 (1932).—The different kinds of enamel are described and their applicability to different types of work is discussed. **II.** *Ibid.*, **65** [52], 923–25 (1932).—The physical and chemical tests usually applied to enamels are described. W.W.B.

**Manufacturing enameled sanitary ware. II. Manufacturing problems.** LOUIS WOLFF. *Better Enameling*, **4** [3], 11–12 (1933).—W. writes on the subjects of furnaces, pattern shop and foundry, formulas and fuels, and safeguards against impurities. For Part I see *Ceram. Abs.*, **12** [5], 183 (1933). W.W.M.

**Enamel as protection against corrosion.** SALMANG. *Oberflächentech.*, **9**, 221–22 (1932).—The enamels must be corrosion proof in order not to attack instead of protect the metal. (*C.A.*)

**Modern enameled metal.** GEOFFREY ARCHBOLD. *Amer. Mag. Art*, **26** [4], 203 (1933).—The Ferro Enamel Corp. is producing enameled steel coffee table tops by H. Edward Winter assuming that the unusual color and design may have a stimulating effect. E.B.H.

**Porcelain enameled house suitable for factory manufacture.** ANON. *Enamelist*, **10** [5], 12 (1933).—Unit No. 1 of a porcelain enameled house group designed by Harry F. Brenner, Architect and Associates, of Cleveland, is described and illustrated. The house is designed to be manufactured and unit-assembled at a central plant, shipped "in a package," and erected at the site with a minimum of delay and uncertainty regarding local building conditions. All the work is supervised under factory methods. W.W.M.

**Enamel tank cars for shipping beer.** GENERAL AMERICAN-PFAUDLER CORP. *Enamelist*, **10** [5], 13 (1933).—The 6000-gallon capacity, glass-lined, steel, refrigerator tank cars of the General American-Pfaudler Corp. are described. Illustrated. W.W.M.

**Radio City's decorations of porcelain enamel.** BERNARD J. MCGARRY. *Enamelist*, **10** [5], 14 (1933).—McG. describes briefly the production of the huge enamel plaques used in the Radio City. These are the first decorations of this character to be used on such a large scale in the world. Two of the plaques are illustrated. See also *Ceram. Abs.*, **12** [5], 178 (1933). W.W.M.

PATENTS

**Protective circuit for enameling furnaces.** R. D. VAN NORDSTRAND (General Electric Co.). U. S. 1,904,580, April 18, 1933.

**Production of signs, decorations, etc.** H. B. LIND (Toledo Porcelain Enamel Products Co.). U. S. 1,905,565, April 25, 1933.

**Coated welding wire.** ROBERT NOTVEST (J. D. Adams Mfg. Co.). U. S. 1,905,648, April 25, 1933.

**Tiled wall, etc.** G. D. HAINES (Porcelain Tile Corp.). U. S. 1,906,583, May 2, 1933.

**Conveyer mechanism.** R. E. TALLEY (George J. Hagan Co.). U. S. 1,906,659, May 2, 1933. The combination with an endless chain conveyer of a support extending the full length of the ware-bearing strand of the conveyer and mechanism for engaging the successive links of the conveyer comprising a segment shaped rocker in constant engagement with the links and a pawl pivotally mounted on the rocker for engaging the links in one direction of its rocking movement.

**Process for producing cloud effects in enamels.** E. S. SMITH (Toledo Porcelain Enamel Products Co.). U. S. 1,907,094, May 2, 1933.

**Knock-down porcelain enameled cabinet.** A. J. SMITH. U. S. 1,907,679, May 9, 1933.

**Enameling process.** E. S. SMITH (Toledo Porcelain Enamel Products Co.). U. S. 1,908,271, May 9, 1933. The process of simulating the appearance of linoleum in enameled surfaces includes the step of covering a surface with a wet coat of frit of predominating color, distributing thereover drops of wet frit of contrasting colors, while still wet partially mixing the colors of the drops with the predominating color and with the colors of each other by means of a stylus, brushing the coating to produce further partial mixing, smoothing the coating, and completing the blending by jolting, drying, and finally fusing.

**Enameling metals.** IGNAZ KREIDL. Austrian 131,116, July 15, 1932. Clouded effects are obtained by adding to the enamel a metal, alloy, or metalloid which reacts with the enamel at the firing temperature with evolution of H. A suitable composition contains Zn 0.2, clay 6, water 45, and enamel mixture 100 parts. (*C.A.*)

**Enameling metal and other surfaces.** OSCAR HOMMEL. Fr. 738,810, June 18, 1932. Decorative effects are obtained by applying materials known to form enamels and one or more powdered vitrifiable products which have a different specific gravity from that of the enamel formers. The whole is then fired. (*C.A.*)

**Fusible enamels for electric wire resistances.** PORZELLANFABRIK PH. ROSENTHAL & CO. A.-G. Ger. 568,248, Jan. 14, 1931. The tendency of the enamel to corrode the wire is reduced by including in the enamel one or more oxides of a metal or metals present in the wire. (*C.A.*)

## Glass

**Selenium ruby glass: preparation and X-ray study.** M. H. BIGELOW AND A. SILVERMAN. *Jour. Amer. Ceram. Soc.*, **16** [5], 214–19 (1933).

**Opal glass. A résumé of the work of the B. S. I. Sub-Committee ELG 3-2 on light-diffusing glass.** S. ENGLISH. *Jour. Soc. Glass Tech.*, **16** [64], 387–98 (1932).—An account is given of the various papers embodying theoretical and experimental data which were considered by the Committee as a starting point for forming a specification for light-diffusing glasses. Special researches were carried on at the National Physical Laboratory, and the results, described in the résumé, were confirmed by independent work carried out at the General Electric Co.'s Research Laboratories. Some of the principal items which any specification must contain are set out. See also *Ceram. Abs.*, **12** [4], 147 (1933). G.R.S.

**Theory and specification of opal diffusing glasses. I.** J. W. RYDE AND B. S. COOPER. *Jour. Soc. Glass Tech.*, **16** [64], 408–30 (1932).—The theory of the diffusion of light by turbid media is presented in a simple form which can readily be applied to practical work in connection with opal glasses. **II.** J. W. RYDE, B. S. COOPER, AND W. A. R. STOYLE. *Ibid.*, **16** [64], 430–49 (1932).—The three fundamental glass constants, $\mu$, $q$, and $NB$, are discussed. A description is given of methods for measuring the photometric quantities from which the constants can easily be determined. It is shown how a figure of merit, assessing the relative suitability of different opal glasses, may be obtained. A method of specifying the intrinsic efficiency of opal glassware to be

used in lighting fittings is outlined. See also *Ceram. Abs.*, **12** [3], 101; [4], 147–48 (1933). G.R.S.

**Aspects of the manufacture of opal glass.** W. M. HAMPTON. *Jour. Soc. Glass Tech.*, **16** [64], 399–407 (1932).—Use was made of the work of Ryde and Cooper on the scattering of light by turbid media (*Ceram. Abs.*, **10** [8], 554 (1931); see also preceding abstract) to ascertain and obtain the condition necessary for the successful manufacture of opal glass. Control of the opalizing materials in the case of fluorides is essential both because of their volatility under varying conditions and because of the corrosion of the refractories which they bring about, the dissolved iron causing a substantial increase in the light absorbed. Reference is made to factory tests on lighting glassware. Some characteristics of flashed opal glasses, pot-opal sheet, and Diffusalyte are described. See also *Ceram. Abs.*, **12** [4], 147 (1933). G.R.S.

**Notes on manufacture of special glasses. XIII. Homogeneity of colorless glasses.** ANON. *Glass*, **10** [3], 98–102 (1933).—The following topics are treated: (1) definition of homogeneity, and (2) causes of inhomogeneity, (*a*) choice of batch materials, (*b*) mixing process, (*c*) melting process, (*d*) flow lines in the furnace, (*e*) refractory attack, (*f*) devitrification, and (*g*) working conditions. For Part XII see *Ceram. Abs.*, **12** [5], 186 (1933). G.R.S.

**Homogenization of glass melts as a deformation process.** H. JEBSEN-MARWEDEL. *Kolloid-Z.*, **60**, 37 (1932).—It is suggested that in silicate glasses there exist chains and sheets of silicate molecules embedded in a true amorphous isotropic matrix. Homogenization is brought about by deforming these chains and sheets until they are completely chaotic in shape and position. This is not a diffusion process. The X-ray interference phenomena may be due to a general one-direction orientation of the molecular chains and sheets, similar to the molecular chain orientation effect known to exist in stretched rubber. (*J.S.G.T.*)

**Behavior of glassforming oxides under high oxygen pressure.** H. MOETTIG AND W. WEYL. *Glastech. Ber.*, **11** [2], 67–70 (1933).—A number of glasses was melted in a high-pressure apparatus under oxygen pressures up to 350 atmospheres. Lead glasses formed plumbates under these circumstances. In some barium glasses barium peroxide was formed. These reactions were used to explain the oxygen content found in optical glasses by Becker and Salmang (*Ceram. Abs.*, **9** [4], 267 (1930)) and also the rôle of barium in the fining of glass observed by Springer. In manganese glasses the oxidation equilibrium was shifted so that 0.1% of MnO gave deep violet glasses under high oxygen pressure. W.W.B.

**Electrical conductivity of sodium metasilicate-silica glasses.** E. SEDDON, E. J. TIPPETT, AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **16** [64], 450–77 (1932).—Determinations were made of the electrical resistance of a series of 14 glasses ranging in composition from $SiO_2$ 50.21%, $Na_2O$ 49.79% to $SiO_2$ 91.6%, $Na_2O$ 8.40%, the temperature range being from below 100 to 560°C. The specific electrical resistance ranged from $2.09 \times 10^8$ to $1.31 \times 10^9$ at 100° and from $71.8$ to $7.53 \times 10^4$ at 400°. G.R.S.

**Temperature measurements on wired glass.** H. E. BECKETT. *Jour. Soc. Glass Tech.*, **16** [64], 382–86 (1932).—Measurements were made on a sample of wired glass exposed to strong sunshine in order to ascertain whether, in such circumstances, the wire can become appreciably hotter than the surrounding glass. No evidence of such an effect was discovered. Large temperature differences were observed between the edge and the center of a sheet of glass in a roof-light of normal construction. Special methods of temperature measurement are described. See also *Ceram. Abs.*, **12** [4], 149 (1933). G.R.S.

**Influence of tension on the elasticity of glass.** OSCAR KNAPP. *Glastech. Ber.*, **10** [12], 644–46 (1932).—The modulus of rupture of some annealed and of some rapidly chilled rods of lime-magnesia glass was measured. After rupturing, the internal stresses in the vicinity of the point of rupture were determined. After determining the relation between the modulus of elasticity and the cross-section of the rods, the variation of the elasticity with the amount of internal stress was calculated. W.W.B.

**Coloring glasses by means of metallic vapors.** JOSEF HOFFMANN. *Sprechsaal*, **66** [6], 96–97 (1933).—Glasses were colored by means of the vapors of the alkali and the alkaline earth metals. Differences in color were found to depend not on the metal used but on the physical state of the metal when it had condensed within the glass. Porcelain was also deeply colored by this means. W.W.B.

**Flexible glass.** A. M. BLUME. *Umschau*, **36** [40], 795 (1932).—By subjecting glass to a special thermal treatment it has been found possible to give it great plasticity and strength and resistance to shocks and strokes. This glass, called Securit, has a

great advantage over safety glass in that it remains colorless and transparent for years. See also abstract by Obst, *Ceram. Abs.*, **12** [6], 220 (1933). M.V.K.

**Prismatic glasses.** J. LE BRAZ. *Glaces et Verres*, **6** [32], 2–10 (1933).—The definition and principles of prismatic glasses are given. Diffusing and "parasol" glasses and their application are also discussed. M.V.K.

**Recent developments in the annealing of hollow ware.** W. A. MOORSHEAD. Presented at meeting of Society of Glass Technology, March, 1933; abstracted in *Pottery Gaz.*, **58** [670], 498 (1933). E.J.V.

**Technique, form, and design in glassmaking.** EDWARD MEIGH. Discussion at meeting of Society of Glass Technology, March, 1933; abstracted in *Pottery Gaz.*, **58** [670], 493–97 (1933). E.J.V.

**Toughened plate glass.** JAMES MEIKLE. Presented at meeting of Society of Glass Technology, April, 1933; abstracted in *Pottery Gaz.*, **58** [671], 601–603 (1933). E.J.V.

**Discussion of a popular soda-lime tank batch.** IRVING E. ADAMS. *Glass Ind.*, **14** [5], 55–56 (1933).—Under the pressure for more production, more fusibility, and more durability the simple glass batches have become modified by the addition of aluminum-containing compounds, borax or some allied boron compound, barium in some form, and quite recently ammonium sulfate. A typical batch which, with slight variations from plant to plant, is in general use is discussed in considerable detail. The reasons for including each ingredient and the percentage included are given. E.J.V.

**New ideas and methods of glassmelting.** I. S. S. BERMAN. *Keram. i Steklo*, **9** [1], 19–21 (1933).—B. discusses the basic defects of modern glassmelting furnaces. M.V.K.

**Development of safety glass.** WALTER BAUER. *Sprechsaal*, **66** [2], 31–33 (1933).—The invention and development of safety glass is chronologically described. W.W.B.

**Polymerization products as intermediate layers for safety glass.** A. BRESSER. *Sprechsaal*, **66** [5], 78–82 (1933).—The efficiency of several polymerization products that are being used as intermediate layers in safety glass is compared on the basis of the following tests which were carried out under uniform conditions and are described in detail: (1) stability on storage in the dark, open to the weather, and in a drying oven at 50, 75, and 100°C; (2) stability in contact with water at 15, 50, and 100°C; (3) resistance to shock and shatterability; (4) transmissibility of light; and (5) stability in contact with oil and solvents. See also *Ceram. Abs.*, **12** [3], 100 (1933). W.W.B.

**Standardization of safety glass.** R. ROEHM AND W. ROEHM. *Sprechsaal*, **66** [2], 24–29 (1933).—The different kinds of safety glass and the characteristic properties of each are described. The five chief tests applied to safety glass, (1) shatterability, (2) stability under light, (3) stability under heat, (4) resistance to moisture, and (5) resistance to atmosphere, are described and critically discussed. By means of numerous quotations from the literature it is shown that the specifications for the tests are far from uniform, and suggestions are made for their standardization. W.W.B.

**Changes in properties of safety glass.** FRITZ OHL. *Glastech. Ber.*, **11** [1], 17–21 (1933).—The effects of heat, ultra-violet irradiation, and moisture on the properties of safety glass and the effect of temperature on its shock resistance were studied. W.W.B.

**After-treatment of safety glass.** HELMUT MERTENS. *Sprechsaal*, **66** [2], 29–30 (1933).—The methods for cutting safety glass and bullet-proof glass and the finishing and polishing of the edges are described. W.W.B.

**Patent situation of the safety-glass industry in Germany.** TH. PESCH. *Sprechsaal*, **66** [2], 30–31(1933).—A review of the patents relating to safety glass held in Germany is given. W.W.B.

**Problems and innovations in the safety-glass industry.** EMIL DIETEL. *Sprechsaal*, **66** [2], 23–24 (1933).—A brief review is given of recent improvements in the safety-glass industry and the problems still confronting the industry are discussed. W.W.B.

**Literature on the use of hard (toughened) glass as a safety glass.** W. ROEHM. *Sprechsaal*, **66** [3], 43–45 (1933).—On the basis of the available literature and patent reports, a brief description of the process involved in producing "hardened" glass is given. The advantages and disadvantages of this glass as a safety glass are presented. W.W.B.

**Constitution and properties of commercial glass.** GUSTAV KEPPELER. *Glastech. Ber.*, **11** [2], 49–58 (1933).—The properties which influence the choice of constituents of commercial glass are those which influence the forming of the glass. Glasses with low temperature softening points are used throughout. Compared with other industrial glasses commercial glass has a high alkali content (14.7 to 15.8%), low lime content (5.2 to 8.5%), and high silica content (74.6 to 78%). The alkali is generally soda.

Potash is used only where repeated reheating is necessary. A glass mass of moderate chemical resistance is essential. Glasses for preserving food must be more resistant than ordinary tableware. W.W.B.

**Glass as a modern building material.** OTTO HERFURTH. *Diamant*, **54** [19], 277–79; [20], 292–93 (1932).—H. discusses the use of plain flat and prismatic glass for window illumination, pointing out the advantages of the greater diffraction of the light by the prismatic glass to give a more even illumination. Different styles of pressed glass floor or sidewalk lights are described. The laying of glass tile flooring according to the Keppeler and Luxfer systems is compared. The use of glass for wall material in making fireproof rooms is taken up, and the need for so installing the glass as to allow for its expansion without any strain is emphasized. Specialized phases of glass applied to construction are pointed out. Illustrated. E.J.V.

**Decorations on glass with glass dust and crushed glass.** OTTO HERFURTH. *Diamant*, **54** [29], 399–401 (1932).—The use of powdered or crushed glass to produce decorative designs by the utilization of various colors and grain sizes of glass melted onto flat glass sheets is described in detail. E.J.V.

**Glass gilding.** W. H. *Diamant*, **54** [33], 447–48 (1932).—Details of several processes for gold coating glass are given. E.J.V.

**Notes on the evaporation of silver, beryllium, chromium, and silicon to form mirrors.** C. H. CARTWRIGHT. *Rev. Sci. Instruments*, **3**, 298 (1932).—An apparatus for volatilizing materials from a tungsten spiral *in vacuo* is described. Silicon mirrors are important in the ultra-violet region on account of their good reflectivity. The material attacks the tungsten heater, and thoria protective linings must be used. A temperature of 2000° is sufficient. (*J.S.G.T.*)

**Cyanite, a new glass material.** ANON. *Ceram. Ind.*, **20** [4], 177 (1933).—There are conflicting opinions with respect to the use of alumina in glass, but its use is increasing in U. S. glass plants. Cyanite is a more concentrated source of alumina than other substances, being 63% $Al_2O_3$ and 37% $SiO_2$. Its presence requires an increase in the glass batch temperature but this is offset by faster operations due to more rapid hardening with sufficient workability of the glass. Properties given glass by alumina are outlined. W.W.M.

**Removal of iron in the sand with chlorides.** OSCAR KNAPP. *Sprechsaal*, **66** [13], 215–18 (1933).—The iron oxide in glass sand was removed with chlorides during the melting process by volatilization as iron chloride. The efficiency of various chlorides in the removal of iron was tested both in raw materials and in glasses. Magnesium chloride in the presence of barium peroxide removed approximately 50% of the iron, so that this salt mixture may serve for the removal of iron in sand and the decolorization of glasses containing iron. W.W.B.

**Testing photographic lenses.** H. W. LEE. *Glass Ind.*, **14** [5], 57–60 (1933).—Stability of optical glass is the first requirement of lens material. Defects likely to occur in optical glass are (1) the presence of extraneous matter, including bubbles, (2) strain, and (3) striæ. These defects are described and methods of detecting them are discussed. Lenses must be tested for chromatic aberration, spherical aberration, photographic focus, light transmission, and flare, as well as focal length. Methods of making each of these tests are described in detail. Illustrated. E.J.V.

**Measuring the maximum intensity of light from the photographic lamp or from other sources of short duration.** W. E. FORSYTHE AND M. A. EASLEY. *Rev. Sci. Instruments*, **3**, 488 (1932).—The length of flash from a photoflash lamp is about 0.06 second, the maximum being about 0.015 second from the commencement of flash. The original method of measuring the intensity was to expose a moving photographic plate through a slit. A quicker method is to receive the light on a photoelectric cell, the current produced leaking through a high resistance. The potential difference across this resistance charges a condenser of short time constant through a rectifying valve, the maximum charge on the condenser being measured by a ballistic galvanometer. The apparatus is calibrated by using stationary lamps of known intensity. The characteristics of several photoflash lamps are given. (*J.S.G.T.*)

**Faults occurring in the Fourcault process and their removal.** ERNST LUCK. *Sprechsaal*, **66** [7], 111–12 (1933).—The occurrence of rough glass, tuyère bubbles, and rills in glass made by the Fourcault process and the prevention of these faults are discussed. W.W.B.

**Glass shaping and boring.** ANON. *Umschau*, **36** [38], 748–49 (1932).—Methods and devices used for shaping and boring glass objects are described. M.V.K.

**Glass industry on the Continent.** W. E. S. TURNER. Presented at meeting of

London Section, Society of Glass Technology, April, 1933; abstracted in *Pottery Gaz.*, **58** [671], 603 (1933). E.J.V.

**Progress in glass technology during 1931–1932 under the auspices of the Glass Research Delegacy.** ANON. *Jour. Soc. Glass Tech.*, **16** [64], 375–81 (1932). G.R.S.

**Progress of the glass industry in 1931.** OSKAR KNAPP. *Glashütte*, **63** [7], 109–11 (1933).—K. gives a short review of the latest investigations dealing with (1) manufacture and protection of cast tank brick, (2) production of special refractories, (3) reasons for breaking of glasspots, (4) attack of tank brick by melting glass, (5) durability of tank brick, (6) corroding power of metallic slag on refractories, (7) grain size of refractories, (8) heat transfer of refractories, (9) action of thermal shock on clay bodies, (10) water permeability of refractories, (11) analysis of sodium water glasses, (12) direct sodium determination, (13) determination of lime, (14) determination of barium sulfate, calcium oxalate, alumina, etc., (15) separation of lead and iron, (16) determination of iron in sand for glass, (17) quantitative determination of boric acid, and (18) determination of fluorine. See also *Ceram. Abs.*, **12** [4], 146 (1933). M.V.K.

**History of glass.** F. H. *Diamant*, **54** [29], 401–402 (1932).—A brief excerpt is given from the history of glass developed in ancient times in the various European countries. E.J.V.

**Business and profit in bottle plants.** K. H. BORCHARD. *Glashütte*, **63** [4], 57–59 (1933).—B. discusses the determination of costs in bottle plants. M.V.K.

BOOK

**Fabrication and Decorative Fashioning of Glass.** JACQUES WOLF. *Pottery Gaz.*, **58** [670], 503 (1933); for review see *Ceram. Abs.*, **12** [4], 150 (1933). E.J.V.

## Book Review

**The Physical Properties and the Melting of Glass.** (Les Propriétés Physique et la Fusion du Verre.) BERNARD LONG. vi + 489 pp. 360 illustrations. 980 diagrams. Price 108F bound, 98F paper pamphlet. Dunod, Paris, 1933. L., Director of the central laboratory of the Saint-Gobain Glassworks, is a technologist of wide reading who recognizes the need for interpretation of the recent literature of glass. The post-war output of research and publication in a number of languages requires assembling and summarizing in order that scientific collaboration in the field of glass may be furthered.

The book is essentially a textbook of glass technology from which certain subjects have been either omitted entirely or treated briefly. There is no extended description of fuels, furnaces, or glassworking processes. The emphasis of the work is placed upon the measurement of physical properties and their significance, the chemistry and physics of the fusion process, and the refractory materials, considered physicochemically.

Following a preface by M. Delloye, Director-General of St.-Gobain, L. outlines his purpose in a foreword and presents an introduction of eight pages, "A View of Glass Manufacture." This is brief and lucid disposing of the more hackneyed phases of glass technology quickly, if not adequately.

Viscosity is given first place among the properties of glass. Chapter I presents the necessary definitions and recognized physical laws, the methods and apparatus for measurement, and the tables and curves exhibiting the data of various investigations. Authors and sources are cited in footnotes.

The chapter on mechanical properties begins with density and a presentation of the additive theory of Winkelmann and Schott. Some of the later work on density and its relation to composition and temperature is recorded. The other mechanical properties are similarly handled. Definitions are clear and precise. A sufficient number of investigators is quoted to illustrate methods, but the chapter is by no means encyclopedic. For example, some of the recent American work on abrasion and brittleness might well have been included.

The chapters on thermal and electrical properties are fuller, and nearly 100 pages are devoted to optical properties with careful exposition of the physics involved and abundant illustrations, diagrams, and absorption curves.

A discussion of the action of water on glass concludes the first portion of the book.

The section on glassmelting begins with silica and its various forms, in which phase diagrams from the Geophysical Laboratory on the soda–lime–silica system are extensively quoted. Glassmaking materials are briefly catalogued, and some pains are taken with the calculation and preparation of batch. There follows a chapter on melting, discussing the reactions during fusion, the molten bath, methods and reagents for refining,

the working condition, and dissolved gases. Faults arising from the melting are treated at length, and there is an adequate study of devitrification.

Annealing and the examination of strained glass by polarized light form an interesting chapter. Leers are not mentioned; the treatment is entirely technical. Tempered glass is given a few pages.

Coloration by oxides of iron is considered separately, and full advantage has been taken of the researches devoted to this important phase of the chemistry of glass. Chapters on decolorizing and on the effect of ultra-violet light and other radiations on colored glasses follow.

A discourse on the vitreous state, constitution, and stability ends the section. Particular attention is paid to equilibria attained under various heat treatments. Speculation as to chemical constitution is avoided.

The third portion of the work is devoted to refractories and is divided between refractory materials not in contact with the glass, those in contact (pots and blocks), and methods and apparatus for the control and study of these materials. It is surprising to find thus occupied one-fifth of a book so cursory in its treatment of other parts of the field of glass technology. When we consider the vital relationship of refractories to glass manufacture, however, we must admit that such a proportion may be justifiably taken.

The volume is well printed in large, clear type, and the reproductions of photographs, diagrams, and curves are neat and distinct. It lacks an index, but the table of contents repeats all essential paragraph headings.

The style is simple and direct with an economy of language that commends the book for reference use. More than a mere compilation, it offers many statements of fact on the writer's own authority.

Certain generalizations are somewhat inaccurate from the viewpoint of American practice. For example, the lime content of glasses is placed between 9 and 15%, whereas much American glass contains less than 8% total CaO and MgO. Dolomite is dismissed as a raw material because of its iron content. Cerium oxide is said to have a feeble coloring power; no mention is made of the ceria-titania combination. Glassmakers' potash is written $K_2CO_3 \cdot 2H_2O$; it is a sesquihydrate.

Such minor differences are easily overlooked, however, in view of the general excellence of the work. S. R. SCHOLES

PATENTS

**Process and apparatus for printing glass sheets.** CLAUDE LOCREILLE. U. S. 1,903,718, April 11, 1933.

**Leer loader.** THOMAS STENHOUSE AND DAVID STENHOUSE (Hazel-Atlas Glass Co.). U. S. 1,903,916, April 18, 1933. S. B. BOWMAN AND THOMAS STENHOUSE (Hazel-Atlas Glass Co.). U. S. 1,906,786, May 2, 1933.

**Method and apparatus for testing incandescent lamps, etc.** W. L. KUBACH (General Electric Co.). U. S. 1,904,059, April 18, 1933.

**Glass tank furnace.** MOTT WYANT. U. S. 1,904,111, April 18, 1933.

**Manufacture of wire glass.** M. L. BEGEMAN (Mississippi Glass Co.). U. S. 1,904,118, April 18, 1933.

**Rotary knife for severing molten glass.** K. E. PEILER (Hartford-Empire Co.). U. S. 1,904,325, April 18, 1933.

**Glass feeder.** DAVID STENHOUSE (Hazel-Atlas Glass Co.). U. S. 1,904,754, April 18, 1933.

**Sign.** JAMES BOYCE AND R. F. HANCOCK (Chicago Glass Novelty Corp.). U. S. 1,904,850, April 18, 1933.

**Glass furnace.** L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 1,904,957, April 18, 1933. T. C. MOORSHEAD AND F. A. HURLBUT (United Glass Bottle Mfrs., Ltd.). U. S. 1,907,361, May 2, 1933.

**Glassware forming machine.** L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 1,904,958 and 1,904,959, April 18, 1933, and 1,906,649, May 2, 1933. J. E. MCLAUGHLIN (Owens-Illinois Glass Co.). U. S. 1,904,982, April 18, 1933.

**Glassworking tank.** L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 1,904,960, April 18, 1933.

**Machine for forming hollow glassware.** L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 1,904,961, April 18, 1933. J. F. RULE. U. S. 1,904,985, April 18, 1933.

**Machine for making glass stoppers.** J. E. COLLINS (Owens-Illinois Glass Co.). U. S. 1,904,977, April 18, 1933. FLOYD FLEXON (Owens-Illinois Glass Co.). U. S. 1,906,561, May 2, 1933.

**Method and apparatus for manufacturing sheet glass.** CARROLL CONE (Libbey-

Owens-Ford Glass Co.). U. S. 1,904,978, April 18, 1933. J. P. CROWLEY (Libbey-Owens-Ford Glass Co.). U. S. 1,906,249, May 2, 1933. FREDERICK GELSTHARP (Pittsburgh Plate Glass Co.). U. S. 1,905,849, April 25, 1933.

**Leer.** F. T. NESBITT (Owens-Illinois Glass Co.). U. S. 1,904,983, April 18, 1933. E. E. MILNER (Ball Bros. Co.). U. S. 1,908,528, May 9, 1933.

**Method of making corrugated wire glass.** ARNO SHUMAN (Pennsylvania Wire Glass Co.). U. S. 1,905,006, April 25, 1933.

**Process and apparatus for making composite glass.** J. H. SHERTS (Duplate Corp.). U. S. 1,905,189, April 25, 1933, and U. S. 1,906,821, May 2, 1933. V. K. BOYNTON (Duplate Corp.). U. S. 1,905,211, April 25, 1933. M. L. MACHT (Duplate Corp.). U. S. 1,906,474, May 2, 1933.

**Manufacture of laminated glass.** E. M. BALL (Libbey-Owens-Ford Glass Co.). U. S. 1,905,430, April 25, 1933. J. C. ZOLA (Duplate Corp.). U. S. 1,908,004, May 9, 1933.

**Apparatus for handling glassware.** E. H. LORENZ (Hartford-Empire Co.). U. S. 1,905,476, April 25, 1933.

**Apparatus for supplying molten glass.** K. E. PEILER (Hartford-Empire Co.). U. S. 1,905,494 and 1,905,495, April 25, 1933.

**Forehearth of glassmelting furnaces.** H. A. WADMAN (Hartford-Empire Co.). U. S. 1,905,533, April 25, 1933.

**Apparatus and method for making glass.** H. A. WADMAN (Hartford-Empire Co.). U. S. 1,905,534, April 25, 1933.

**Ophthalmic lens.** M. A. LAABS (American Optical Co.). U. S. 1,905,644, April 25, 1933. The process of producing lenses in quantity comprises grinding a plurality of lens blanks simultaneously to a given lens power, the ground surface being curved and the opposite surface being plano, placing the blanks over a shaped portion of a refractory block and submitting them to heat to cause them to subside into the shaped portion of the block, the shaped portion being such that the subsided blank will have substantially the same lens power as it had before subsidence but its plano form will have been changed to a meniscus form.

**Ophthalmic lens.** H. W. HILL (American Optical Co.). U. S. 1,907,810, May 9, 1933.

**Apparatus for making plate glass.** WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 1,905,743, April 25, 1933.

**Glass-drawing apparatus.** J. H. REDSHAW (Pittsburgh Plate Glass Co.). U. S. 1,905,748, April 25, 1933.

**Machine for grinding and polishing optical lenses, spectacle glasses, etc.** JOSEF DESENBERG. U. S. 1,906,050, April 25, 1933.

**Glass-blank transfer.** FRANK O'NEILL. U. S. 1,906,086, April 25, 1933.

**Glass-cutting machine.** O. C. NATLIS (Libbey-Owens-Ford Glass Co.). U. S. 1,906,279, May 2, 1933. L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 1,906,650, May 2, 1933.

**Process of a machine for working glass.** C. W. DAVIS AND F. F. BECKER (Mantle Lamp Co.). U. S. 1,906,315, May 2, 1933.

**Plate glass grinding apparatus.** S. P. MERMER (Commercial Savings Bank & Trust Co.). U. S. 1,906,329, May 2, 1933.

**Glass-rolling apparatus.** J. H. FOX (Pittsburgh Plate Glass Co.). U. S. 1,906,563, May 2, 1933. J. H. FOX AND WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 1,906,564, May 2, 1933.

**Process and apparatus for melting glass by electricity.** H. F. HITNER (Pittsburgh Plate Glass Co.). U. S. 1,906,594, May 2, 1933.

**Mechanism for handling glassware.** O. C. K. HUTCHINSON (Owens-Illinois Glass Co.). U. S. 1,906,604, May 2, 1933.

**Leer feeder.** O. C. K. HUTCHINSON (Owens-Illinois Glass Co.). U. S. 1,906,605, May 2, 1933.

**Glassmelting furnace.** GARLAND LUFKIN (Owens-Illinois Glass Co.). U. S. 1,906,695, May 2, 1933.

**Portable glass-cutting and dressing machine.** F. B. CARRUTHERS (William H. Large). U. S. 1,906,739, May 2, 1933.

**Multiple glass-cutting machine.** C. F. KLAGES AND N. H. KLAGES (G. W. Klages & Son). U. S. 1,907,297, May 2, 1933.

**Machine for molding glass pieces.** O. R. STEPHEN. U. S. 1,907,410, May 2, 1933.

**Glass-shaping mechanism.** K. E. PEILER (Hartford-Empire Co.). U. S. 1,907,570, May 9, 1933.

**Annealing furnace.** C. E. FRAZIER (Simplex Engineering Co.). U. S. 1,907,777, May 9, 1933.

**Process and means for undercutting and sealing laminated glass, etc.** F. M. GREGG, F. N. CAMPBELL, AND JULES MYATT (Bessie L. Gregg). U. S. 1,908,142, May 9, 1933.

**Apparatus for completing pressed blown ware or blown ware.** R. J. BEATTY (Federal Glass Co.). U. S. 1,908,303, May 9, 1933.

**Multicolored glass rod and method for making.** C. A. BEST (Morgantown Glass Works). U. S. 1,908,306, May 9, 1933.

**Apparatus for grinding and polishing glass plates.** F. B. WALDRON (Pilkington Bros., Ltd.). U. S. 1,908,580, May 9, 1933.

**Discharge of molten glass through an outlet.** L. MELLERSH-JACKSON. Brit. 390,580, April 20, 1933.

**Timing apparatus applicable for use with glass-feeding devices, etc.** J. T. WOOD. Brit. 390,883, April 26, 1933.

**Glass-feeding devices.** J. T. WOOD. Brit. 389,923, April 5, 1933.

**Method and apparatus for drawing glass tubes and canes.** CORNING GLASS WORKS. Brit. 391,060, April 26, 1933.

**Drawing window glass in sheets.** NAAMLOOZE VENNOOTSCHAP HOLLANDSCHE MAATSCHAPPIJ VOOR DE VERVAARDIGING VAN GLAS. Brit. 391,066, April 26, 1933.

**Safety glass.** C. F. BOEHRINGER & SOEHNE G.M.B.H. Fr. 737,804, May 30, 1932. Cellulose esters, particularly the acetate, are brought into sheet form by plastification by means of glycerol ethers, esterified in at least one OH group, *e.g.*, diglycerol tetracetate. The sheets are used for uniting two sheets of glass. (*C.A.*)

**Press for uniting sheets of safety glass.** ADOLF KÄMPFER AND ADOLF C. PLÖTZE. Fr. 737,827, May 30, 1932. (*C.A.*)

**Rolling machine for glass.** N. V. MAATSCHAPPIJ TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Fr. 738,112, June 3, 1932. (*C.A.*)

**Apparatus for rolling complex bands of glass.** PILKINGTON BROS., LTD. Fr. 738,231, June 6, 1932. (*C.A.*)

**Molds for glass articles.** COBELETERIE DE GIVORS (SOC. ANON.). Fr. 738,687, June 16, 1932. (*C.A.*)

**Glassmaking crucibles.** MAX HOLLENWEGER. Fr. 739,091, June 25, 1932. The clay used is adapted to the temperature of service of the crucibles, a finely ground quartz or glass composition being added as required. As binder a porcelain mixture is prepared; it is thinned by fine refractory clay and quartz of medium grain, and this assumes a concretionary state of the temperature of service of the crucibles. For the porcelain mixture the same composition of glass is used as that which is to be melted in the finished crucible. (*C.A.*)

**Mechanical production of ampoule parts.** "ISO" G.M.B.H. Ger. 548,400, Sept. 20, 1930. (*J.S.G.T.*)

**Feeding batch to melting furnaces; preheating.** G. KEPPELER. Ger. 548,530, Nov. 13, 1928. The canal or tunnel furnace, through which the batch is fed by suitable transporting devices to the furnace, is heated by the waste gases coming from the furnace. See also *Ceram. Abs.*, **9** [4], 275 (1930). (*J.S.G.T.*)

**Glassblowing machine.** BORNKESSEL BRENNER UND GLASMASCHINEN G.M.B.H. Ger. 549,877, Feb. 15, 1927. In order to reduce as much as possible the breadth of the machine, the suction and pressure cylinders having a common piston rod are disposed along the longitudinal axis of the machine. (*J.S.G.T.*)

**Blowheads for semi-automatic machines.** BORNKESSEL BRENNER UND GLASMASCHINEN G.M.B.H. Ger. 550,067, April 27, 1930. The blowhead mounted at the end of a flexible lead is operated by hand independently of the machine. (*J.S.G.T.*)

**Arrangement of rolls for producing sheet glass.** Y. BRANCART. Ger. 550,442, Oct. 10, 1929. (*J.S.G.T.*)

**Production of glass threads.** BORNKESSEL BRENNER UND GLASMASCHINEN G.M.B.H. Ger. 550,443, Oct. 25, 1927, and Ger. 550,529, June 5, 1930; see also *Ceram. Abs.*, **11** [6], 365 (1932). (*J.S.G.T.*)

**Delivering mold charges.** W. J. MILLER, INC. Ger. 550,587, Nov. 25, 1928. An indicator of the position of the plunger with relation to the feeder orifice is provided by a rod working in conjunction with the plunger but outside the feeder, this rod being shaped like the plunger at its lower end and working in a cup like the feeder outlet. (*J.S.G.T.*)

**Continuous cutting of sheet glass.** F. GLEISSNER AND A. PETER. Ger. 550,880, July 2, 1930. The cutting table is tiltable from the vertical to the horizontal so that the

sheet after cutting, as it comes upward from the drawing machine, is brought to a horizontal position and is carried away by a conveyer. (*J.S.G.T.*)

**Multi-orifice glass feeder.** UNITED GLASS BOTTLE MFRS., LTD. Ger. 551,956, June 19, 1931. A feeder provided with more than one outlet orifice and corresponding plunger has independently regulated driving mechanism for each one. (*J.S.G.T.*)

**Glassblowing machine.** W. KAEBER. Ger. 552,029, March 20, 1930. Means are provided on a multi-arm rotating blowing machine for electrically controlling suction, parison, and finish blowing operations as well as the air pressure at any individual unit or station, and, in addition, these controls can be actuated individually or can be linked together in any desired combination. (*J.S.G.T.*)

**Production of contact eye lenses.** GEBRÜDER MÜLLER-WELT. Ger. 553,843, Nov. 30, 1930. Lenses which can be applied directly to the cornea of the eye are produced from tubing by blowing into a mold of suitable curvature and then melting off the lower half of the spherical surface corresponding with that of the human eye. (*J.S.G.T.*)

**Production of wired glass.** MISSISSIPPI GLASS CO. Ger. 553,844, April 17, 1930. (*J.S.G.T.*)

**Pressing insulators and internal screws.** WHITALL-TATUM CO. Ger. 554,332, Aug. 16, 1928. A multi-mold press provided with a plunger adapted to unscrew from the glass after pressing is provided with separate plunger tips mounted on a swinging arm over each mold to coact with the common plunger and unscrewing mechanism. (*J.S.G.T.*)

**Take-out device for bottles.** ALBION BOTTLE CO., LTD. Ger. 554,726, Dec. 24, 1930. A device for inverting bottles coming down a chute from a forming machine and placing them on a conveyer band is described. (*J.S.G.T.*)

**Drawing flashed sheet glass.** NEUE GLASINDUSTRIE G.M.B.H., WEISSWASSER O.-L. Ger. 554,727, May 16, 1931. One or both edges of a debiteuse as used in the Fourcault process is provided with a recess running along its edge which can be filled with the colored glass and this is drawn up as a thin layer by the ascending sheet of clear glass drawn through the central slit. (*J.S.G.T.*)

**Production of hollow glassware.** GLASFABRIK SOPHIENHÜTTE RICHARD BOCK, G.M.B.H. Ger. 555,102, Jan. 14, 1930. Hollow ware is blown in molds with rotation of the glass therein, and additional glass is applied through an opening provided in the mold. When hollow pieces are thus applied, the soft wall of the main body can be blown through at the point of attachment by further application of air pressure. (*J.S.G.T.*)

**Golden luster on glass.** SIKAKITI HAMAGUTI. Japan. 94,062, Jan. 7, 1932. $Cl_2$ is passed into an aqueous solution of $FeCl_2$, and the solution is mixed with $H_2O_2$. The solution is sprayed on a glass surface heated to 700° to produce a golden luster. (*C.A.*)

## Structural Clay Products

**De-airing stiff-mud bodies by means other than the vacuum method.** H. R. STRAIGHT. *Jour. Amer. Ceram. Soc.*, **16** [6], 251–55 (1933).

**Use of tribarium aluminate in structural clay products.** W. K. CARTER AND R. M. KING. *Jour. Amer. Ceram. Soc.*, **16** [6], 265–68 (1933).

**Brick unit provides new system of construction.** ANON. *Brick Clay Rec.*, **82** [4], 138–40 (1933).—New brick units of different design, diamond shaped, have been developed, combining the principles of trabeated and arch construction, to form an entirely new system based on the pediment used in ancient Egyptian construction and the pendentive used by Byzantine architecture. Besides making a strong wall, the Bridal brick provides unlimited decorative possibilities and is good for reinforced brick floors. Illustrated. E.J.V.

**Unit for earthquake-proof reinforced brick masonry.** WALTER SIMONS. *Brick Clay Rec.*, **82** [4], 127–28 (1933).—A new shape of common brick, having indented slots along the top and sloped edges along one side, is being used in Los Angeles for earthquake-proof brick masonry. Used in conjunction with a cement grout and thin reinforcing bars, it can be laid into masonry that tests $2^1/_2$ times stronger than standard brick construction. To date its principal use has been the construction of earthquake-proof chimneys. Another application is in building a waterproof inner bond wall. Illustrated. E.J.V.

**Vitrified salt-glazed *vs.* concrete-plaster sewer pipe.** MAURICE BARRETT. *Brit. Clayworker*, **42** [492], 17–18 (1933).—The material selected for the construction of a

sanitary sewer must (1) be inert and absolutely unaffected by any liquids or gases which may pass through or be generated in the system, (2) not disintegrate by either external or internal conditions, (3) have smooth surfaces so as to reduce to a minimum frictional resistance to the flow, (4) be absolutely watertight to prevent contamination of the surrounding soil, and (5) be sufficiently strong to resist either internal or external pressure. Concrete, from its nature, can not resist the action of waste acids and noxious gases which are increasing in amount each year. There is ample evidence to show that the gases in solution in sewage act injuriously on concrete pipe, particularly when the following conditions prevail: (*a*) a high degree of putrescence of the sewage, (*b*) a moistened surface which holds or absorbs the putrid gases, and (*c*) a free air supply. In spite of the fact that vitrified clay pipes have been in use for over 5000 years, no failure due to sewage disintegration has been recorded. B. points out the many defects possible in the use of concrete sewer pipe. R.A.H.

**Relation of bond between brick and mortar and leaky masonry walls.** E. F. GALLAGHER. *Brick Clay Rec.*, **82** [4], 133–34 (1933).—The work of Walter C. Voss, professor of Building Construction at Massachusetts Institute of Technology, in investigating the subject of bond between brick and mortar primarily as it relates to the problem of leaky masonry walls is briefly discussed. Some of the series of tests conducted are described. E.J.V.

**Comparison of the efficiency of different fillers.** H. SEGER AND E. CRAMER. *Tonind.-Ztg.*, **57** [25], 295–96 (1933).—Several products used for fillers were compared. These materials are used in preventing efflorescence on face brick, in decreasing the permeability of roofing tile, in tightening heavy dams or walls against the penetration of water, etc. The products investigated may be divided into the following groups: (1) fluorine containing substances, (2) products containing bituminous, tarry, or other film-forming substances, (3) substances in solution, and (4) products to be added to the concrete or plaster. Test cubes and balls were made from lime and cement mortars and treated with the different substances. Tables show the results of permeability tests at normal and elevated pressures. Several fillers were found to give results satisfactory for different purposes. W.M.C.

**Clay plant economies. Progress report of Technical Committee No. 11.** NATIONAL BRICK MFRS. RESEARCH FOUNDATION. *Bull. Amer. Ceram. Soc.*, **12** [5], 146–53 (1933).

**Data. XV.** T. W. GARVE. *Clay-Worker*, **99** [4], 136–37 (1933).—Descriptions and uses of and data on book tile, conduits, coping, drain tile, and flowerpots of different sizes and types are given. For Part XIV see *Ceram. Abs.*, **12** [6], 245 (1933). E.J.V.

**Calculation of drain pipe.** H. SCHEVEN. *Tonind.-Ztg.*, **57** [24], 288–89 (1933).—A sample is given for calculating the costs of drain pipe of different size. W.M.C.

**Green-food silos of brick construction.** ANON. *Tonind.-Ztg.*, **57** [28], 331–32 (1933).—Different types of brick silos are described of circular and elliptic cross-sections. Common brick or tile of a special shape may be used. Special care should be given to a good heat insulation. Illustrated. W.M.C.

**Brick silos for agricultural purposes.** ANON. *Tonind.-Ztg.*, **57** [26], 309–10 (1933).—Hard-fired brick of special shape are proposed for the construction of silos. The German government is supporting financially the building of new silos for agricultural products. W.M.C.

**Three-day meeting for brickmakers.** ANON. *Tonind.-Ztg.*, **57** [14], 159–62; [16], 185–87; [18], 213–14 (1933).—Technical papers read at the 1933 meeting include (1) "Machinery of brick plants in times of depression," by G. Hartmann; (2) "Comparison of the economy of different types of kilns," by F. Singer; (3) "Factors influencing the price of brick," by Uchtenhagen; (4) "Manufacturing new products in brick plants," by B. Spitta; (5) "Methods for plant control," by W. Dawihl; and (6) "Hollow tile and standard brick," by Kuchler. Full discussions of all papers are given. W.M.C.

**Brick buildings and fortifications at Ribnitz, Germany.** KÜHL. *Tonind.-Ztg.*, **57** [30], 354–55 (1933).—Ribnitz has been commemorating its 700th birthday. A number of fine old brick buildings is described. Illustrated. W.M.C.

## PATENTS

**Process of promoting the bloating of earthy materials.** S. Q. LEE (American Face Brick Research Corp.). U. S. 1,903,821, April 18, 1933. The process of promoting bloating consists in adding to a mass of earthy material a liquid containing molasses and $FeSO_4$ in solution, incorporating it throughout the mass of earthy material, and in subjecting the mass to temperatures adequate to first evaporate the solvent portion of the liquid and thereafter cause bloating by fusing the earthy material and cause a reaction resulting in the liberation of gases throughout the mass.

**Wall structure and building block used therein.** OTTO SANDER AND KASPER KÖNIG (Zeta-Bauweise G.m.b.H.). U. S. 1,903,881, April 18, 1933.

**Ornamental brick and method of production.** E. C. HERVEY (Hydraulic-Press Brick Co.). U. S. 1,905,170, April 25, 1933.

**Brick edging machine.** G. E. LUCE (Lancaster Iron Works). U. S. 1,905,477, April 25, 1933.

**Hollow brick or tile molding machine.** LARS FRANDSEN. U. S. 1,906,744, May 2, 1933.

**Brick siding.** H. D. BROWN. U. S. 1,908,313, May 9, 1933.

**Process for the manufacture of porous articles of clay.** A. NIELSEN. Brit. 390,331, April 12, 1933.

## Refractories

**Silica as a refractory material.** C. N. WITHEROW. *Brick Clay Rec.*, **82** [4], 123–24 (1933).—W. discusses the fundamental properties of both free and combined silica. The rôle of silica in some special refractories is taken up in detail. The stability and range of the crystalline forms of silica and both the chemical and physical properties thereof are enumerated. The low thermal conductivity and electrical conductivity of silica are stressed. E.J.V.

**Fire brick.** ANON. *Blast Fur. Steel Plant*, **21** [4], 227–28 (1933).—Excerpts from the discussion of "Chemistry of a fire brick," by J. F. Hyslop (*Ceram. Abs.*, **12** [6], 229 (1933)), published in the *Jour. West Scot. Iron & Steel Inst.*, are given. These include a discussion of chemical composition, properties tested in laboratories, physical condition of the brick, and the form of aluminum silicate present. For discussion see *Ceram. Abs.*, **12** [6], 229 (1933). E.J.V.

**Refractory materials.** ALEXANDER H. HAYS. *World Power;* abstracted in *Metals & Alloys*, **4** [2], 55 (1933).—A general discussion is given of (1) fire clays, silica, volume changes, and transitions of silica at various temperatures, (2) high-alumina refractories such as bauxite, diaspore, sillimanite, mullite, and corundum, (3) chromite refractories and dolomite, (4) magnesite, (5) silicon carbide, (6) zirconia, and (7) properties of refractories. E.P.R.

**Characteristics of special refractory products. IV.** MARCEL LÉPINGLE. *Rev. mat. constr. trav. pub.*, No. 282, pp. 51–54*B* (1933).—Data on German, American, French, and Swedish refractories are discussed. Among special refractories, corundum, silicon carbide, zirconium, and chromite brick are discussed and their characteristics are given. For Part III see *Ceram. Abs.*, **12** [6], 227 (1933). M.V.K.

**Sintered corundum.** ANON. *Umschau*, **36** [26], 510–15 (1932).—A detailed discussion of the manufacture, properties, and application of sintered corundum is given. See also *Ceram. Abs.*, **12** [6], 226 (1933). M.V.K.

**Refractory materials for induction furnace.** R. J. SARJANT. *Fuel Econ.*, **7** [74], 67–70 (1931); abstracted in *Jour. Inst. Metals*, **50** [3], 199 (1932).—Tests of crucibles made of magnesite, zircon ball clay mixtures, silica, and magnesia-zircon mixtures are briefly discussed. Methods of finishing the top of the lining of coreless induction furnaces are referred to, and future developments in induction furnace linings are briefly discussed. F.G.H.

**Refractories in the metallurgical industry.** A. T. GREEN. Abstracted in *Iron Coal Trades Rev.*, **126** [3389], 227 (1933).—A lecture before the Coördinating Committee describes the manufacture and properties of fireclay and silica refractories. W.E.R.

**Open-hearth furnace regenerator brick.** ANON. *Blast Fur. Steel Plant*, **20** [1], 116–18 (1932); abstracted in *Metals & Alloys*, **4** [2], 55 (1933). E.P.R.

**Sectionally supported furnace walls.** ANON. *Fuel Econ.*, **8** [88], 255–59 (1933).—The causes of failure of refractories in boiler furnaces are described. The water-cooled wall has stimulated development of the refractory furnace. Each has its own field, the water-cooled furnace in the high capacity, high load factor installation, and the refractory furnace in the lower capacity, low load factor installation. The sectionally supported air-cooled wall is discussed. W.E.R.

**Notes on kiln markings of fireclay brick.** S. M. KIER. *Heat Treating & Forging*, **17** [12], 1139–40 (1931); abstracted in *Metals & Alloys*, **3** [12], 360 (1932); see also *Ceram. Abs.*, **11** [6], 373 (1932). E.P.R.

**Comparison of the rates of flow of water and of air through refractory materials.** F. H. CLEWS, E. O. MILLS, AND A. T. GREEN. *Feuerfest*, **9** [2], 25 (1933); for abstract see *Ceram. Abs.*, **11** [10], 530 (1932). M.V.K.

**Heat losses from furnace walls.** J. H. WRIGHT. *Iron Coal Trades Rev.*, **126** [3394], 415–16 (1933); abstracted in *Power & Fuel Bull.*, **3** [27], 42 (1933).—The advantages of insulation are mainly (1) reduction of loss of heat by conduction, radiation, and convection resulting in cumulative savings depending mainly upon the life of the refractory and insulation, (2) evenness of temperature distribution throughout the furnace, (3) less time and heat required to attain working temperature, (4) possibility of reduction of spalling, and (5) reduction of total heat capacity of the wall. Some of the disadvantages are as follows: Insulation, in the absence of efficient furnace temperature control, renders the wall more liable to overheating. Insulating materials themselves are generally weak and friable; they will not withstand steam and corrosive influences, their refractoriness is low, and their capacity for absorbing moisture is high. W.E.R.

**Heat losses in furnace operation.** S. N. BRAYSHAW. *Iron Coal Trades Rev.*, **126** [3395], 464–65 (1933); abstracted in *Power & Fuel Bull.*, **3** [27], 46 (1933).—B. discusses the discriminate application of refractories and thermal insulating materials to furnaces heated with gas, oil, and electricity. The value and design of doors for furnaces are also discussed. W.E.R.

**Action of zinc in blast furnaces.** W. FELDMANN. *Stahl & Eisen*, **52** [52], 1290 (1932); abstracted in *Iron Coal Trades Rev.*, **126** [3389], 223 (1933).—The volatilized zinc penetrates the pores of the lining, where it becomes oxidized and expands. The lining becomes soft, and avenues are opened for the penetration of carbon with the result that a gradual crumbling of the lining takes place. W.E.R.

**Use of coke-oven gas in open-hearth furnaces.** F. WESEMANN. Assn. of German Ironmasters Steel Works Comm. *Rept.*, No. 247; abstracted in *Iron Coal Trades Rev.*, **126** [3393], 390 (1933).—W. discusses the effect of the use of coke-oven gas on refractories. W.E.R.

**Continuous furnaces and soaking pits.** G. R. MCDERMOTT. *Iron Coal Trades Rev.*, **126** [3385], 41–43; [3386], 76–78 (1933).—A review of recent developments in these furnaces is given, with emphasis on the performance of an improved "pressure" gas burner which gives a uniform high temperature over a comparatively large area of the hearth, resulting in more uniform heating of ingots or slabs. Several recent installations are cited. Illustrated. W.E.R.

**Refractory service with particular reference to boiler furnaces.** JOHN WALKER. *Engineering*, **135**, 4–7, 34–37 (1933); for abstract see *Ceram. Abs.*, **11** [4], 249 (1932). H.H.S.

**Influence of furnace size on fuel consumption in pig iron production.** E. C. EVANS. *Iron Coal Trades Rev.*, **126** [3391], 296–97 (1933).—E. mentions the need for improvement in refractories and the possibility of insulating stack. W.E.R.

**Progress in the refractory field, in building, and in firing ceramic furnaces in England in 1932.** W. STEGER. *Feuerfest*, **9** [3], 33–41 (1933).—The discussion deals with (1) refractory materials: (*a*) advantages in using silica in coke ovens, (*b*) behavior of silica brick in continuously operated vertical retorts, (*c*) use of unfired brick for the linings of induction furnaces, (*d*) researches on the souring of dead-burned magnesite, and (*e*) new method for determining the stability against scorification of refractory materials; (2) ceramic furnaces: (*a*) semi-rotary furnaces for frit melting, (*b*) new electric furnace with stationary hearth and traveling tunnel, (*c*) ventilators in the preheating and cooling zones of tunnel kilns, (*d*) heat balance of an annular kiln for firing brick, and (*e*) oil firing in the brick industry. M.V.K.

**Development of refractories in 1931.** ANON. *Blast Fur. Steel Plant*, **20** [1], 59 (1932); abstracted in *Metals & Alloys*, **4** [2], 55 (1933). E.P.R.

**Present state of refractory standardization in the most important countries of the world.** L. LITINSKY. *Feuerfest*, **9** [2], 17–25 (1933).—Standard specifications of the German, French, English, American, Russian, and Czechoslovakian refractory products are discussed. A literature index dealing with the subject is given. M.V.K.

BULLETIN

**Applying petrographic methods to refractories research.** L. J. TROSTEL. Amer. Refrac. Inst. *Tech. Bull.*, No. 37, 7 pp. (1933).—T. indicates the value and limitations of petrographic studies which disclose crystalline changes not shown by chemical analysis or physical test. The petrographic microscope and auxiliaries, such as refractive index liquids, apparatus for preparation of thin sections, camera, and quenching furnace, are briefly described. The experience of most of the laboratories that have used petrographic methods is that the insight gained regarding composition and reaction of the products more than compensates for the rather high cost. W.E.R.

PATENTS

**Casting of aluminum silicate refractories.** F. W. SCHROEDER (Corhart Refractories Co.). U. S. 1,903,944, April 18, 1933.

**Means for retaining furnace wall blocks against tubes.** E. G. BAILEY AND R. M. HARDGROVE (Fuller Lehigh Co.). U. S. 1,904,189, April 18, 1933.

**Method and apparatus for utilizing radiant heat energy.** GUSTAV EGLOFF AND L. A. MEKLER (Universal Oil Products Co.). U. S. 1,904,361, April 18, 1933.

**Arch, particularly for use in metallurgical furnaces.** WALTER ALBERTS (Vereinigte Stahlwerke A.-G.). U. S. 1,904,596, April 18, 1933. In a furnace an arch is built up of brick individually having profiles of a plurality of types of curved configuration on the surface of the arch which is out of contact with the fire and is exposed to the air.

**Furnace lining.** G. D. EVANS (American Smelting and Refining Co.). U. S. 1,906,557, May 2, 1933. The method of forming a furnace lining comprises impregnating the furnace walls with molten copper, subjecting the interior of the furnace to oxidizing conditions whereby the copper is partially converted to copper oxides, adding finely divided silica to the molten copper and copper oxides whereby the silica becomes bonded in a matrix of the oxides, and repeating the operation until a coating of substantial thickness has been built up.

**Side wall construction.** J. S. BENNETT (American Engineering Co.). U. S. 1,906,835, May 2, 1933.

**Impregnated silicon carbide article and the manufacture thereof.** A. H. HEYROTH (Globar Corp.). U. S. 1,906,963, May 2, 1933.

**Checker brick.** C. J. A'HEARN. U. S. 1,907,170, May 2, 1933.

**Checker-brick system.** F. M. MILLER. U. S. 1,907,852, May 9, 1933.

**Checkerwork.** J. P. GRILLI. U. S. 1,908,143, May 9, 1933.

**Refractories.** WALTER SCHOTTLER. Fr. 739,021, June 24, 1932. Refractory articles are made by heating quartzite, amorphous or in small crystals, to about 1000°, cooling, grinding, mixing with milk of lime, and hardening by steam under pressure. (*C.A.*)

**Molding refractory objects.** CORNING GLASS WORKS. Fr. 738,115, June 3, 1932. The mold is partially filled with a core of solidified refractory material, the remaining space being filled by a single stream of molten refractory material. Fr. 738,116. In the mold is placed a refractory support, a large part of the surface of which constitutes a wall of the hollow of the mold and sufficient molten refractory material is introduced to melt this support. Fr. 738,117. Pieces of calcined and fused material are introduced into the mold and have sufficient density to sink in the molten material. (*C.A.*)

**Silica brick.** MAX HOLLENWEGER. Fr. 738,241, June 7, 1932. Large-grained quartz, etc., is mixed with finely divided quartz (passing a sieve of 10,000 holes per sq. cm.), lime, and/or clay, a mixture in which the proportions of $SiO_2$, clay, and/or lime are regulated so that the agglutinating mass fuses at the temperature of firing the brick. The mixture is molded and fired. (*C.A.*)

**Alumina.** FÉLIX JOURDAN. Fr. 738,665, June 15, 1932. Pure $Al_2O_3$ is obtained from bauxites even if rich in $SiO_2$ by adding to the bauxite a salt or rock containing NaOH or KOH and CaO, the amounts being calculated so as to fix all the $Al_2O_3$ as aluminates of Na or K and Ca and all the $SiO_2$ as mono- or di-Ca silicate. The mixture is ground, heated till fusion begins, cooled, and again ground. $NaAlO_2$ or $KAlO_2$ is recovered by washing and converted to $Al_2O_3$. (*C.A.*)

**Silica blocks.** HERMANN SALMANG AND BENNO WENTZ. Ger. 557,286, July 23, 1931. The molded mixtures of $SiO_2$, CaO, MgO, etc., are fired at temperatures below 1400° and preferably at 1250°, to form blocks. See also *Ceram. Abs.*, **12** [4], 161 (1933). (*C.A.*)

## Terra Cotta

**Zirconium glazes developed for heavy clay products.** C. J. KINZIE AND C. H. COMMONS. *Brick Clay Rec.*, **82** [4], 132–33 (1933).—Specially attractive properties of zirconium glazes developed for heavy clay products include irreducibility, nonreactivity, stable opacity, durability, and uniformity of surface. E.J.V.

**Weather-proof red uranium glazes.** HANS ESKA. *Sprechsaal*, **66** [4], 59–61; [5], 77–78; [6], 93–96; [7], 109–10; [8], 127–29 (1933).—A series of experiments on various types of uranium glazes shows that sodium oxide has the strongest negative influence on the red coloration of these glazes. To obtain red glazes with sodium uranate a low

quartz content is necessary. As a consequence these glazes have a low resistance and discolor noticeably in slightly acid atmosphere. Uranium glazes of higher quartz content, which can be made in the absence of $Na_2O$, are harder and more resistant to atmosphere. If a red color is to be obtained with lead or lead-barium glazes, the silica content must be at least 1.2 mols. If, however, 0.10 to 0.20 mol of ZnO, $CaF_2$, MgO, or $K_2O$ are added, the silica content must be increased up to 1.4 to 1.6 mols if bright red colors are to be obtained. The same is also true for the addition of $B_2O_3$. The increased quartz content increases the weather resistance, as do some of the oxides that may be added. The glazes consisting of 1.0 mol of PbO, 0.1 mol $Al_2O_3$, 0.2 mol $UO_3$, and 1.2 to 1.6 $SiO_2$ are not sufficiently resistant to the influence of acids in the atmosphere. Their resistance is increased through the addition of BaO, $CaF_2$, $K_2O$, and $B_2O_3$. The kaolin content should not be more than 0.1 mol, for higher kaolin additions decrease the weather resistance considerably. Only the zinc glazes become more resistant by the addition of more kaolin. Kaolin additions make the colors produced less intense. Exceptions to this are the pure lead and lead-barium glazes. Uranium oxide may be added in amounts up to 0.15 or 0.20 mol. Care must be taken in using pure raw materials, since small amounts of impurities greatly decrease the intensity of the red glazes. The best firing temperature is 940 to 960°C. These uranium glazes have approximately the same coefficient of expansion as bodies that contain clay and quartz in approximately the same amount plus 20 to 30% of dolomite, lime, or magnesite. The bisque firing temperature of the body should be higher than the temperature to which the enamel is fired. Building tile to which uranium glazes are to be applied should be previously fired until vitreous. W.W.B.

**Firing stoneware in a reducing atmosphere.** A. DAHL. *Tonind.-Ztg.*, **57** [27], 323–24 (1933).—D. discusses the papers by Hauser and Dorfner (*Ceram. Abs.*, **12** [6], 232 (1933)). He proposes the use of a gas-fired ring kiln with separate chambers or the electric kiln for firing stoneware products. These kilns are more economical. W.M.C.

## White Wares

**Effect of mechanical pressure on the imbibitional and drying properties of some ceramic clays. II.** A. E. R. WESTMAN. *Jour. Amer. Ceram. Soc.*, **16** [6], 256–64 (1933); for Part I see *Ceram. Abs.*, **11** [11], 593 (1932).

**Studies on drying. I.** G. BOZZA. *Milano Rendiconti*, **64**, 409 (1931).—The phenomena associated with the drying of a solid substance, which may or may not undergo deformation during the process, are critically examined. Reference is made to certain inaccuracies in the work of previous authors on the subject and complete differential equations are given corresponding to the surrounding conditions. Less complicated conditions involving no contraction and no variability in the coefficient of diffusion during the drying are considered, and the equations are applied to nonhygroscopic substances for the periods of humidity both above and below the critical temperature. A quantitative relationship is thus obtained between humidity and time. The method of deducing the necessary coefficients (of evaporation and diffusion) from practical drying experiments is explained. **II.** G. BOZZA AND I. SECCHI. *Ibid.*, **64**, 464 (1931).—Consideration is given to the problem of determining the coefficient of evaporation, $a$, under experimental conditions in which an exhaustive research on drying is to be developed. The relation given by $a$ when the vapor tension of the air can not be regarded as constant over all the drying surface is deduced, and the relationship between the coefficient $a$ and the velocity of the air is then determined based on nearly 500 determinations. (*T.C.S.E.*)

**Manufacturing control of dry-pressed porcelain.** FRANK CERMAK AND L. E. THIESS. *Bull. Amer. Ceram. Soc.*, **12** [5], 138–40 (1933).

**Effect of crypto-crystalline silica on whiteware bodies.** GEORGE BLUMENTHAL, JR. *Ceram. Ind.*, **20** [4], 180–81 (1933).—B. gives results of an investigation made on the effect of using crypto-crystalline silica in semivitreous and vitreous tableware and sanitary ware bodies. Tabular and graphic data are presented on water of plasticity, volume drying and firing shrinkage, dry and fired transverse strength, vitrification behavior, fineness of ground quartz, french flint and crypto-crystalline silica, and behavior in jiggering, casting, and drying. The addition of crypto-crystalline silica is claimed to prevent dunting of the ware. The reasons for this are its extreme fineness and more ready solution in the bodies. W.W.M.

**Properties of English china clays.** T. A. KLINEFELTER, W. W. MEYER, AND E. J. VACHUSKA. *Jour. Amer. Ceram. Soc.*, **16** [6], 269–76 (1933).

**Die filling, hardness, and wedging of dust-pressed tile.** HARRY W. WEBB. Presented at meeting of English Ceramic Society, March, 1933; abstracted in *Pottery Gaz.*, **58** [670], 504 (1933). E.J.V.

**Scientific study of principal products for house floorings. II.** F. CHALAMEL. *Rev. mat. constr. trav. pub.*, No. 282, pp. 47–50*B* (1933).—C. discusses practical means for determining the nature (structure, porosity, hardness, and wearing) of fired and unfired products. For Part I see *Ceram. Abs.*, **12** [6], 233 (1933). M.V.K.

**Methods by which a small plant can produce tile at the same cost as its large competitors. III.** D. SEUX. *Rev. mat. constr. trav. pub.*, No. 282, pp. 45–47*B* (1933); for Part II see *Ceram. Abs.*, **11** [11], 587 (1932). M.V.K.

**Speedy methods of ascertaining moisture contents in pottery, etc.** STEPHEN STANWORTH. Presented at meeting of English Ceramic Society, April, 1933; abstracted in *Pottery Gaz.*, **58** [671], 595–97 (1933). E.J.V.

**Health and working conditions in English potteries.** W. H. GRINDLEY. *Times Eng. Supp.*, **31**, 416 (1933).—Steady improvement in the elimination of risks to the health of workers has been made in connection with green fettling, provision of substitutes for flint imbedding, the polishing process, impervious flooring, and dust extraction. H.H.S.

BULLETIN

**Technical publications of the Bureau of Standards relating to white ware.** ANON. Bur. Stand. *Letter Circular*, 131-*A*. Free. 6 pp. This circular lists all reports dealing with chinaware, sanitary ware, electrical porcelains, etc., that have been published by the Bureau and tells where such reports may be consulted. R.A.H.

PATENTS

**Insulating bushing.** H. M. ACLY (General Electric Co.). U. S. 1,906,829, May 2, 1933.

**Electrodeposition of porcelain.** H. M. KRANER (Westinghouse Electric & Mfg. Co.). U. S. 1,907,984, May 9, 1933.

**Ceramic containers for fluid resistances and methods for the production thereof.** HERMSDORF-SCHOMBURG-ISOLATOREN GES. Brit. 390,199, April 12, 1933.

**High-tension electrical insulators.** STEATIT-MAGNESIA AKT.-GES. Brit. 390,269, April 12, 1933.

**Teapots.** I. H. WILSON. Brit. 391,013, April 26, 1933.

**Ceramic compositions.** WALTER BLOCH. Fr. 738,222, June 6, 1932. Compositions having a high density after firing are made from refractory substances such as refractory clays, oxides, silicates, nitrides, carbides, etc. These are fritted and fired in the dense state at a low temperature by means of a mixture of clay and talc which forms a eutectic mixture. (*C.A.*)

## Equipment and Apparatus

**Comparison between diffused and transmitted light in the case of fine particles.** A. BOUTARIC. *Rev. d'Optique*, **11**, 145 (1932).—Numerous types of apparatus, known as Tyndall or néphélé meters, can be employed for investigating the effects of fine particles, the intensity of the effects depending on the number and dimensions of the particles, the index of refraction of the particle material, and the refractive index of the containing liquid. Although interesting results can be obtained from such an apparatus for either suspensions or colloidal solutions, it is clear, from theoretical considerations developed here, that these results can not be interpreted in a simple manner. No proportionality is found to exist between the variations of the coefficient of diffusion, *i.e.*, the ratio between the light diffused normally and the transmitted light, as given by the apparatus, and the absorption coefficient or optical density of the medium. Using gum mastic suspensions, relations are obtained between optical density (related to absorption) and the intensity of light diffused at right angles to the incident beam, good agreement being obtained between the theoretical and experimental curves. The intensity of the diffused light is found at first to increase rapidly with increasing concentration, then less rapidly, passing through a maximum, and finally decreasing. (*J.S.G.T.*)

**Practical clayworking. II.** ANON. *Brit. Clayworker*, **42** [492], 9–11 (1933).—A brief discussion of electrical power production, electrical units, switchboard, motors,

transmission, and cost as applied to brickworks is given. For Part I see *Ceram. Abs.*, **12** [4], 169 (1933). R.A.H.

**Low-temperature comparator for coefficient of expansion of ceramic bodies.** H. E. DAVIS. *Jour. Amer. Ceram. Soc.*, **16** [5], 229–31 (1933).

**Thermocouples and the reproducibility of their data. Criteria for their usefulness in measuring temperatures.** W. GOERDECKE. Festschrift zum 50-jährigen Bestehen der Platinschmelze G. Siebert G.m.b.H., Hanau, pp. 72–99 (1931); abstracted in *Jour. Inst. Metals*, **50** [2], 94 (1932). F.G.H.

**Reflection measuring device.** L. BERGMANN. *Z. tech. Physik*, **14** [4], 157–58 (1933).—Light reflection from surfaces has been measured by a new device using a selenium photronic cell with a diaphragm. Values are obtained for direct and indirect reflection. W.M.C.

**Calorimeter with high frequency operated measuring arrangement.** H. ESSER AND W. GRASS. *Arch. Eisenhüttenwesen*, **6**, 353–56 (1933).—The lag of temperature readings will decrease the accuracy of measurements with ordinary calorimeters. The metal receptacle which receives the sample to be tested is being used now as a condenser in a high-frequency circuit. The thermal expansion of the metal will change the capacity of the condenser. A second condenser, used for compensating the change, is part of a circuit oscillating uniformly. The thermal expansion of the receptacle is determined from the change of oscillations, and the heat content of the sample is calculated from the thermal expansion of the receptacle. The accuracy of the method is 0.5%. W.M.C.

**Vacuum calorimeter for high temperatures.** L. G. CARPENTER AND T. F. HARLE. *Proc. Phys. Soc.* [London], **44** [243], 383–99 (1932); abstracted in *Mech. Eng.*, **54** [8], 600 (1932).—A platinum-thermometer vacuum calorimeter, suitable for the determination of true specific heats at high temperatures, is constructed without any organic insulating materials. Heat is transferred from the platinum coil to the calorimeter by radiation. F.G.H.

**Combined temperature and humidity recorder.** CAMBRIDGE INSTRUMENT CO. *Instrument World*, **4**, 218 (1932); abstracted in *Jour. Inst. Metals*, **50** [4], 242 (1932). F.G.H.

**Improving automatic control by recorder chart interpretation.** W. R. CLENDINNING. *Chem. Met. Eng.*, **40** [3], 123–25 (1933).—Successful chart interpretation must be based on a consideration of all the information a chart can give, including the factor of time. This time factor is the least well known but the most important feature of satisfactory control. Problems met in control are classified and the methods of solving each are indicated. G.R.S.

**Magnetic impurity detector.** GENERAL ELECTRIC CO. *Chem. Met. Eng.*, **40** [3], 152 (1933).—Magnetic impurities in asbestos, mica, glass, sand, and similar materials are detected and their extent is measured by a new magnetic device. G.R.S.

**Special alloys resistant to heat.** W. HERRMANN. *Feuerungstechnik*, **20** [8], 114–16 (1932); abstracted in *Chim. & ind.*, **29** [3], 588–89 (1933).—H. discusses the use of nickel-chromium alloys and their properties. The higher the chromium content the greater is the resistance to oxidation at high temperatures. Additions of silicon (2%) greatly ameliorate the refractory properties of the alloys. M.V.K.

**Theory of the functioning of crushers with cylinders having an axial movement.** G. BARBEROT. *Rev. mat. constr. trav. pub.*, No. 282, pp. 43–44*B* (1933).—A discussion of the coefficient of grinding and of the axial movement is given. M.V.K.

**Continuous filter press.** THOMPSON CONTINUOUS FILTER PRESS CO. *Ceram. Ind.*, **20** [4], 202 (1933).—This unique press is illustrated and described in detail. It requires a small amount of floor space and trials have shown it to be efficient. W.W.M.

**Ash-removal equipment for boilers.** F. RIEDIG. *Feuerungstechnik*, **20** [8], 123–25 (1932); abstracted in *Mech. Eng.*, **54** [11], 816 (1932).—Ash-handling equipment is discussed under the following headings: (1) mechanical equipment, (2) gravity conveyers, (3) shaking conveyers with electromagnetic drive, (4) conveyers with and without pump drive, (5) hydraulic equipment, and (6) pneumatic and portable equipment. F.G.H.

**Economies of superheated steam in brickworks.** CHAS. F. WADE. *Brit. Clayworker*, **42** [492], 13–14 (1933).—The use of a suitable degree of superheat in the steam creates a sequence of economies which in the aggregate amount to a substantial figure, covering the first cost of the installation in a short period of time, especially if an efficient steam drier and purifier is also installed. The sequence of economies is reviewed and given as follows: (*a*) improvement of boiler efficiency, (*b*) reduction in steam main losses, (*c*) beneficial effect on steam consumption of engines, and (*d*) drying and purification. R.A.H.

**Metal wear in the refractories industry.** C. E. BALES. Amer. Refrac. Inst. *Tech. Bull.*, No. 36 (1933).—B. discusses the wear of metals in dry pans, wet pans, screens, pug mills, auger machines, brick, machine dies, and press dies, the effect of such wear on the quality of refractories, and the selection of suitable metals or alloys resistant to the wear characteristic of each service. Metal wear in the refractories industry is an important factor from the standpoint of the cost of renewal of certain parts as well as its effect on the quality of product. The situation can be improved by coöperation between the firebrick plant management, equipment maker, and metallurgist. W.E.R.

**De-airing machine for potteries.** CHAMBERS BROTHERS CO. *Ceram. Ind.*, **20** [4], 202 (1933).—A smaller size of de-airing machine has been designed especially for pottery plant use. The machine and its use are described. W.W.M.

**Screen-angle indicator.** ANON. *Chem. Met. Eng.*, **40** [3], 152 (1933).—A device known as the Angle-O-Meter is used to assist in the proper installation of vibrating screens. G.R.S.

**Wire screens.** J. W. GALLOWAY. *Can. Mining Jour.*, **53** [8], 360–62 (1932); abstracted in *Mech. Eng.*, **54** [12], 872–73 (1932).—The construction of four different wire screens, (1) double crimp, (2) intermediate crimp, (3) high and low tooth, and (4) the "Flatlock," is described in detail. Wires of varying composition, size, and hardness are discussed with respect to cost and resistance to abrasion. Illustrated. F.G.H.

**Differential draft control.** ANON. *Chem. Met. Eng.*, **40** [3], 154 (1933).—The instrument regulates the amount of air passing through the furnace in accordance with the natural draft of the stack and the fuel rate. G.R.S.

**Portable draft gage.** HAYS CORP. *Chem. Met. Eng.*, **40** [3], 153 (1933).—Using a slack-leather diaphram instead of a liquid-sealed manometer, a new portable, pointer-indicating draft gage has been developed. Graduations read to 0.01 in., water gage. G.R.S.

**Avoiding pitfalls in pump-suction systems.** M. J. REED AND L. H. MORRISON. *Chem. Met. Eng.*, **40** [3], 142–43 (1933).—A detailed analysis is given of the most vulnerable part of any pumping system. G.R.S.

**Coal, clay, and sand handling by steel band conveyers.** ANON. *Eng. Boiler House Rev.*, **45** [9], 585–87 (1932); abstracted in *Mech. Eng.*, **54** [6], 452 (1932).—Details are given of a combined steel conveying system which handles 60 T. of coal, 40 T. of clay, and 40 T. of wet or dry sand per hour. F.G.H.

**Economic factors affecting the use of carbide-tipped milling cutters.** M. ROMAINE. *Machinery* [N. Y.], **38** [9], 665–69 (1932); abstracted in *Mech. Eng.*, **54** [8], 599 (1932).—Applications of cemented tungsten and tantalum carbide for blades of milling cutters are described. The possibility of using higher speeds and feeds and the cutting of hitherto unmachineable materials are discussed. F.G.H.

## BOOK

**Fundamentals of Instrumentation. Part I of the Manual of Instrumentation.** M. F. BEHAR. Instruments Publishing Co., Pittsburgh, Pa., 1932. 109 pp. 50 illustrations. Price $2.00. Reviewed in *Mech. Eng.*, **54** [11], 806–807 (1932). F.G.H.

## PATENTS

**Loading of sewer pipe, building tile, etc., for railway shipment.** I. H. SPOOR (Gerrard Co., Inc.). U. S. 1,903,841, April 18, 1933.

**Vibrating screen.** B. E. GREEN (Huron Industries, Inc.). U. S. 1,905,393, April 25, 1933.

**Screening apparatus.** M. P. REYNOLDS (W. S. Tyler Co.). U. S. 1,906,336, May 2, 1933.

**Process and apparatus for forming articles of plastic clay.** L. J. FRIEDL. U. S. 1,906,566, May 2, 1933.

**Drying equipment.** W. W. SIBSON AND H. H. BELCHER (Philadelphia Drying Machinery Co.). U. S. 1,907,220, May 2, 1933.

**Clay-tempering machine.** DAVIS BROWN. U. S. 1,907,731, May 9, 1933.

**Air-conditioning substance.** F. A. HESSEL. U. S. 1,907,809, May 9, 1933. A composition of matter contains set plaster of Paris and a substantial amount of an efflorescent salt capable of evolving water vapor so as to maintain effectively the atmosphere in a chamber in a relatively humid condition.

**Mixing apparatus.** K. S. VALENTINE (Turbo-Mixer Corp.). U. S. 1,908,002, May 9, 1933.

**Brick machine.** H. E. DUNN (W. E. Dunn Mfg. Co.). U. S. 1,908,640, May 9, 1933.

**Pottery-molding machines.** H. SCHANTZ. Brit. 391,034, April 26, 1933.

## Kilns, Furnaces, Fuels, and Combustion

**Stresses in domes and crowns of circular kilns.** J. N. GOODIER. *Jour. Amer. Ceram. Soc.*, **16** [5], 220–28 (1933).

**Oil-fired furnaces.** S. F. UNWIN. *Jour. Inst. Metals*, **53** [1], viii (1933).—The important features and the variety of uses of petroleum fuel oils are described. Various forms of furnaces and oil burners which are applicable to oil firing are discussed. Considerable data on the cost and consumption of fuel oil are presented. F.G.H.

**Firing a continuous kiln with natural gas.** MARK A. TAYLOR. *Brick Clay Rec.*, **82** [4], 135–36 (1933).—In changing from oil firing to natural gas firing of an 18-chamber continuous kiln, the Vincent Clay Products Co. found many advantages. One burner had provision for the use of low-pressure air, while the other was the venturi tube inspirator type; the latter proved the better. The oil-firing schedule was followed with less difficulty than if oil were being used. Several advantages of gas are pointed out. E.J.V.

**Experimental researches on the different gas burners for furnaces.** M. STEFFES. *Chaleur et ind.*, **13**, 231 (1932).—Five types of burners were studied to find the effect of pressure variations and the efficiency of combustion. Diagrams are given of the burners which are of three main types, (1) simple injection, (2) injection and rotation, and (3) rotation. (*J.S.G.T.*)

**Comparison of economy of different types of furnaces.** F. SINGER *Tonind.-Ztg.*, **57** [24], 283–88 (1933).—Graphs are given comparing the economy of ring, zigzag, and tunnel kilns. The gas-fired tunnel kiln is the most economic one for common brick provided that mineral coal is expensive and that the gas producer will be fired with cheap coal. For roofing tile, single periodic and groups of periodic kilns, ring, zigzag, and tunnel kilns are compared. The most satisfactory results are found with the ring and zigzag kilns. When roofing tile show only a small strength during firing, the tunnel kiln may be used just as well. The same furnaces, except the zigzag kiln, are compared for hard-fired brick. For these products, the tunnel kiln is found to be the most economic one. W.M.C.

**Lowering fuel consumption in annular kilns.** K. D. *Ziegelwelt*, **64** [8], 77 (1933).—Directions on how to operate annular kilns are given. M.V.K.

**Fundamentals and economies in the clay industries. XXVI.** ELLIS LOVEJOY. *Clay-Worker*, **99** [4], 134–35 (1933).—L. takes up the downdraft kiln, explaining the various constructions used in its building and the advantages of each type of construction and flue arrangement. Some points which should receive careful attention in the construction of all periodic kilns are pointed out. For Part XXV see *Ceram. Abs.*, **12** [6], 238 (1933). E.J.V.

**Recent developments at the Royal Doulton factory.** ANON. *Pottery Gaz.*, **58** [670], 489–92 (1933).—A description of the new circular tunnel kiln for biscuit firing and the new building for pottery decorating with an electric decorating kiln is given. Illustrated. E.J.V.

**Apparatus for controlling manufacture in brick plants.** R. REH. *Tonind.-Ztg.*, **57** [30], 355–56 (1933).—Two cases are cited in which considerable savings have been obtained by controlling the water-smoking and chimney draft of ring kilns. W.M.C.

**Utilization of town gas for pottery firing.** A. MACKAY. *Pottery Gaz.*, **58** [671], 610–13 (1933).—Reasons for the increased use of town's gas for heat treatments of pottery are summarized as follows: (1) It is essentially a fuel which can easily and completely be burned in burners of simple construction. (2) The combustion of gas so burned is under complete control so that any desired furnace atmosphere may be obtained. (3) As the air-gas ratio is high the regeneration of waste heat by the air used for combustion is a relatively simple matter. (4) Low sulfur content results in the furnace atmospheres being free from contaminating gases. (5) Control of temperatures and furnace atmospheres is simple. (6) Floor space of furnaces is reduced, no chimney is required, and capital expenditure is lowered. (7) No handling of original fuel or residue is necessary. (8) Smoke is eliminated. (9) Maintenance cost of the furnace is very much reduced. (10) Town's gas is a fuel of constant composition and consequently this simplifies the maintenance of constant and uniform temperatures. (11)

There is less damaged or scrapped material as a result of imperfect heat treatment. These points are discussed in detail. See also *Ceram. Abs.*, **12** [2], 74 (1933). E.J.V.

**Slide nomographs applied to gas-works routine calculations.** T. H. BLAKELEY. *Gas Jour.*, **200** [3632], 860–61 (1932).—The construction of a slide nomograph to be used in gas calculations is shown and its use explained. G.R.S.

**Heat of expansion of a gas of varying mass.** L. J. GILLESPIE AND J. R. COE. *Jour. Chem. Phys.*, **1** [1], 103–13 (1933).—Equations are given for the direct treatment of experiments in which not only heat but masses pass the boundary of the container of the system during the experiment. The bearing of the results on variable-pressure calorimetry, as practiced in experiments on the heat of adsorption, is briefly discussed. G.R.S.

**Influence of ionization on the ignition temperature of combustible gases.** B. LEWIS AND C. D. KREUTZ. *Jour. Chem. Phys.*, **1** [1], 89–94 (1933).—The ignition temperatures of methane-"air" mixtures were investigated in a flow system as follows: (1) the spontaneous ignition temperature due to temperature alone was determined; and (2) one of the inert gases was passed through a condensed discharge before joining the combustible gas and the change in ignition temperature was noted. It is concluded that electrically charged species or ions are responsible for the lowered ignition temperatures. G.R.S.

**Demonstration of oil-burning equipment.** ANON. *Glass*, **10** [3], 96–97 (1933).—A newly developed ignition and flame chamber enables any grade of liquid fuel to be used and to be lit instantly from cold, while enabling any length or type of flame to be obtained. Three photographs show one of the small burners in operation. G.R.S.

**Measurement of flow of gases and vapors.** B. F. DODGE. *Ind. Eng. Chem.*, **24** [3], 261–73 (1932); abstracted in *Mech. Eng.*, **54** [6], 453 (1932).—D. reviews modern methods which are extensively used for continuously measuring and recording gas flow. F.G.H.

**Determination of coefficient of transfer of heat between a solid wall and a gas current.** E. BRUN AND P. VERNOTTE. *Acad. Sci.*, **195** [4], 302–304 (1932); abstracted in *Mech. Eng.*, **54** [11], 814 (1932). F.G.H.

**Developments and trends in mechanical engineering.** ANON. *Mech. Eng.*, **54** [12], 845–58 (1932).—Recent developments in the utilization of oil, coal, and gaseous fuels and improvements in cemented tungsten carbide are described. F.G.H.

**Tests on combustion processes in a pulverized coal fire.** H. SCHWIEDESSEN. *Arch. Wärmewirt.*, **13** [4], 105–106 (1932); abstracted in *Mech. Eng.*, **54** [7], 525 (1932).—The temperature and composition of flue gases and the time required for their burning are discussed. F.G.H.

**Selection of coal to meet critical conditions.** J. E. TOBEY. *Power Plant Eng.*, **36** [19], 746–49 (1932); abstracted in *Mech. Eng.*, **55** [1], 70 (1933). F.G.H.

**Combustion of pulverized coal.** L. NISOLLE AND A. BODMER. *Tech. moderne*, **24** [14], 449–55 (1932); abstracted in *Mech. Eng.*, **55** [1], 72 (1933).—Ignition temperatures of various types of coal are considered. The effect of the particle size of coal is discussed. F.G.H.

**Use of coal in the ceramic industry.** JOSEF DORFNER. *Sprechsaal*, **65** [51], 905–906 (1932).—Methods of obtaining greater coal economy in ceramic plants are discussed. W.W.B.

**Standard states for bomb calorimetry.** EDWARD W. WASHBURN. Bur. Stand. *Jour. Research*, **10** [4], 525–58 (1933); R.P. No. 546.—An examination of the thermodynamics of the conditions existing in bomb calorimetry shows that the heat of combustion per unit mass of substance burned is a function of the mass of sample used, of the initial oxygen pressure, of the amount of water placed in the bomb, and of the volume of the bomb. To eliminate the effects of these, at present, unstandardized variables and to obtain a more generally useful thermal quantity which characterizes the pure chemical reaction for stated conditions, it is suggested that every bomb-calorimetric determination be first corrected to give the value of the change of "intrinsic" energy for the pure isothermal reaction under the pressure condition of 1 normal atmosphere for both reagents and products. From this value the heat of the pure reaction at a constant pressure of 1 atmosphere is readily calculable. An equation for calculating the correction and an equation for correcting to any desired standard temperature the heat measured in the bomb calorimeter are given. R.A.H.

**Thermal insulation and insulating materials.** ANON. *Chem. Age* [London], **27** [676], 199–202 (1932); abstracted in *Mech. Eng.*, **54** [11], 814 (1932).—Various methods for reducing the loss of heat by radiation and convection from furnaces are discussed.

The shrinkage, fusion point, and evaluation of insulating materials and the testing methods involved are considered. F.G.H.

**Aluminum foil heat insulation.** T. A. SOLBERG. *Jour. Amer. Soc. Naval Eng.*, **44** [2], 200–205 (1932); abstracted in *Mech. Eng.*, **54** [12], 886 (1932). F.G.H.

**March of electrochemistry.** C. L. MANTELL. *Chem. Met. Eng.*, **40** [3], 120–22 (1933).—An outline and diagram are given of the development of electrochemistry from 1800 to the present. Northrup's high-frequency furnace and the electrical furnace for clear fused quartz are shown. G.R.S.

**Low-temperature carbonization in brick retorts.** ANON. Dept. Sci. Ind. Research *Tech. Paper*, No. 35; abstracted in *Iron Coal Trades Rev.*, **126** [3390], 254 (1933). W.E.R.

**Analysis of chimney-draft equations.** J. C. SMALLWOOD. *Mech. Eng.*, **55** [1], 32–34 (1933). F.G.H.

**Combined low-temperature carbonization and combustion.** D. BROWNLIE. *Eng. Boiler House Rev.*, **45** [10], 622–25 (1932); abstracted in *Mech. Eng.*, **54** [7], 525 (1932). F.G.H.

**Calorific values of fuel by calculation.** E. L. JOHNSON. *Colliery Eng.*, **9** [97], 87 (1932); abstracted in *Mech. Eng.*, **54** [6], 452 (1932).—J. describes a rapid, reliable, and simple method of calculating the actual calorific value of any fuel from the usual commercial analysis. F.G.H.

BOOK

**Analysis of Fuel, Gas, Water, and Lubricants.** S. W. PARR. International Chemical Series. McGraw-Hill Publishing Co., London, 1932. Reviewed in *Chem. & Ind.*, **52** [10], 225 (1933); see also *Ceram. Abs.*, **11** [8], 466 (1932). G.R.S.

PATENTS

**Apparatus for and method of heat treating ceramic materials.** JOSEPH HARRINGTON (Joseph Harrington Co.). U. S. 1,906,465, May 2, 1933. In heat treating, the apparatus includes a chamber for receiving a supply of ware to be treated, means for supplying heated gases, a flue for conducting the heated gases into the chamber, and means for introducing a supercharge of air within the flue for association with the heated gases.

**Brickmaking process in which quick drying and firing are combined in a single operation.** FRANCO BANDINI. U. S. 1,906,785, May 2, 1933.

**Silicon carbide resistor and manufacture thereof.** ERNST HEDIGER (Globar Corp.). U. S. 1,906,853, May 2, 1933.

**Pulverized fuel feeding stoker.** F. C. PICKARD (Standard Stoker Co., Inc.). U. S. 1,908,047, May 9, 1933.

**Kiln truck.** H. M. ROBERTSON. U. S. 1,908,186, May 9, 1933.

**Brick kilns.** A. HABLA. Brit. 389,689, March 29, 1933.

**Tunnel kilns.** J. WEDGWOOD & SONS, LTD. AND N. WILSON. Brit. 390,358, April 12, 1933, and 391,057, April 26, 1933.

## Geology

**Leucite: source of alumina, potash, and silica.** G. A. BLANC. *Trans. Inst. Chem. Eng.*, **9**, 49 (1932); abstracted in *Ind. chimique*, **20** [230], 181–82 (1933).—Leucite lavas of Italy contain such a quantity of iron that it makes possible their magnetic enrichment after crushing. In these conditions a mineral containing 22 to 23% $Al_2O_3$, 17 to 18% $K_2O$, 53 to 55% $SiO_2$, and traces of Ca, Na, and Fe is obtained. Alumina and potassium are dissolved by treating with hydrochloric or nitric acid which leaves a mass of silica hydrogel. If a certain amount of colloidal silica is in suspension in the liquid, the latter is purified by filtration. The heat of reaction liberated during the treatment with the acid is sufficient for maintaining the reaction which takes place at 80 or 90°. The slightly acid liquid is cooled and KCl is separated by crystallization. Some hydrochloric gas is added, the temperature is increased to 70°, and hydrated $AlCl_3$ is deposited. Impurities such as Fe, Na, and a certain quantity of KCl are separated on cooling. When using sulfuric acid for treating, potash alum is obtained. $AlCl_3$ or $Al(NO_3)_3$ are easily decomposed in a rotary furnace. The alumina obtained contains some water; it is soluble in cryolite and is therefore considered as a new molecular form of $Al_2O_3$. M.V.K.

**Origin of tektites.** L. J. SPENCER. *Nature*, **131** [3300], 117–18 (1933).—Tektites

are small pieces of green, brown, or black glass found in nature. They have been called moldavites, australites, obsidianites, billitonites, and Darwin glass. They contain 70 to 89% silica in their composition. The present most generally accepted view is that they are meteoric. J.L.G.

**New ideas for utilization of nephelite in industry.** P. A. VOLKOV. *Compt. rend. acad. sci.* [U.S.S.R.], **A**, pp. 165–72 (1932).—Decomposition of nephelite (approximate composition $2Na_2O{\cdot}K_2O{\cdot}3Al_2O_3{\cdot}6SiO_2$) was found to proceed according to $2Na_2O{\cdot}K_2O{\cdot}3Al_2O_3{\cdot}6SiO_2 + 12H_2SO_4 + nH_2O = 2Na_2SO_4{\cdot}Al_2(SO_4)_3 + K_2SO_4{\cdot}Al_2(SO_4)_3 + 6SiO_2 + (12 + n)H_2O$. The use of nephelite solution in $H_2SO_4$ is suggested as a substitute for $Al_2(SO_4)_3$ in the paper industry. It is also estimated that from 1 part of nephelite 1.91 parts of $Na_2SO_4{\cdot}Al_2(SO_4)_3{\cdot}24H_2O$ and 0.79 part of $K_2SO_4{\cdot}Al_2(SO_4)_3{\cdot}24H_2O$ can be prepared. Decomposition of 1 T. of nephelite according to the method described yields 0.35 T. of silica gel and 2.4 alum with 1.25 T. of $H_2SO_4$ required for the process. Other products from nephelite such as $Al_2O_3$, ultramarine, lac substitutes, and laundry blue can be obtained by action of $SO_2$ gas in the presence of water: $2NaO{\cdot}K_2O{\cdot}3Al_2O_3{\cdot}6SiO_2 + 15SO_2 + nH_2O = 4NaHSO_3 + 2KHSO_3 + Al_2(SO_3)_3 + 6SiO_2 + (n - 3)H_2O$. (*C.A.*)

**Origin and classification of pegmatites.** K. K. LANDES. *Amer. Mineralogist*, **18** [3], 95–103 (1933).—Acid, intermediate, and basic pegmatites are discussed. G.R.S.

**Purification and utilization of quartz and muscovite mica.** FRANK J. ZVANUT. *Ceram. Ind.*, **20** [2], 94–97 (1933).—Z. reports the results of work done on Pacific Northwest kaolins by the U. S. Bureau of Mines. Clay washing, uses of kaolin, uses of mica, foundry sand, separation of quartz from mica, tests of molding sands, and glass and potters' flint are the subjects briefly covered. W.W.M.

**Structure of the fibrous zeolites.** W. H. TAYLOR, C. A. MEEK, AND W. W. JACKSON. *Z. Krist.*, **84** [5–6], 373–98 (1933).—The structures of natrolite, scolecite, mesolite, and thomsonite were investigated with the aid of data obtained from rotation photographs. G.R.S.

**Crystal structure of zunyite, $Al_{13}Si_5O_{20}(OH,F)_{18}Cl$.** L. PAULING. *Z. Krist.*, **84** [5–6], 442–52 (1933).—The X-ray examination of zunyite showed the cubic unit of structure to have $a_0 = 13.82$Å, and the symmetry of space group $T_d^2 - F\bar{4}3m$. The unit contains 4 molecules, the calculated density being 2.897 g./cm.$^3$ G.R.S.

**Mixed crystal formation in the ternary system, An–Ab–Cg.** E. DITTLER AND A. KOHLER. *Mineralog. petrog. Mitt.*, **43** [4–5], 352–61 (1932).—The structure of carnegieite silicates in plagioclase was systematically studied. It was established by means of chemical and optical studies that with a Cg content of 40% in the initial mixture there was always formed a Cg-free plagioclase with 70 to 90 mol. % An. The carnegieite portion of the melt went entirely into the ground mass where it formed mixed crystals with the remaining anorthite according to Bowen. With higher An portions in these the separation into constituent parts could be established. G.R.S.

**Quantitative analysis of calcite-aragonite mixtures by X-rays.** E. G. COX AND T. H. GOODWIN. *Chem. & Ind.*, **52** [9], 172 (1933).—An analysis can be carried out by comparing the relative intensities of a calcite and an aragonite line in a photograph of the sample with the relative intensities of the same lines in a photograph of a suitable standard mixture. A diagram of the lines is given. G.R.S.

**United States Geological Survey.** W. C. MENDENHALL. *Sci. Monthly*, **36**, 104–20 (1933).—The origin, organization, field work, mapping, water finding, finances, and cooperative links of the Survey are described. See also *Ceram. Abs.*, **12** [3], 126 (1933). H.H.S.

**State-wide study of Tennessee clays.** GEORGE I. WHITLATCH. *Clay-Worker*, **99** [4], 146 (1933).—A survey which will include both field and laboratory investigation of clays and shales in all parts of Tennessee is being undertaken by the Tennessee Division of Geology. Details which will be covered are enumerated. E.J.V.

**Lepidolite deposit in Colorado.** E. B. ECKEL. *Jour. Amer. Ceram. Soc.*, **16** [5], 239–45 (1933).

**Triplite from La Rioja Province, Argentina.** A. P. HENDERSON. *Amer. Mineralogist*, **18** [3], 104–105 (1933).—Analyses indicate unusually pure triplite. Several tons were located. G.R.S.

**Quartz-cyanite rocks in Unst.** H. H. READ. *Mineralog. Mag.*, **23** [140], 317–28 (1933).—This is a geological treatise on the quartz-cyanite rocks of the Shetland Islands of Scotland. These rocks occur as vein-like bodies in cyanite-chloritoid schists. The rocks immediately associated with the quartz-cyanite rocks are much richer in cyanite and usually wholly free from quartz. R. believes that the rocks have been formed by a process of endogenous secretion during a period of metamorphism and that their complementary portion is indicated by the silica-poor country rock immediately adjacent to

them. The paper is divided into two portions, the first dealing with the description and origin of the Unst rocks and the second with more general aspects. A.K.

**Bauxite occurrence at Halimba, Hungary, and its industrial value.** ISTVÁN VITÁLIS. *Bányász. Kohász Lapok*, **65**, 362–68, 386–92 (1932).—Present methods can not be used for working up these ores. The pisolite-containing matter could perhaps be used by reduction and magnetic separation for production of Fe ore, cement, and a hydrated Al-bauxite ore. The transitionary bauxite ores containing little $SiO_2$ but much Fe should be studied in regard to a new method for their utilization. (*C.A.*)

**Deposits of raw materials used in the ceramic industry.** VICTOR CHARRIN. *Génie civil*, **102** [1], 6–9 (1933).—C. discusses the texture of feldspathic rocks and its importance in the formation of kaolin or clay as the different characteristics of the latter depend on it. The feldspathic region of Saint-Chélly-d'Archer (Lozère) and kaolins of Brittany are described. See also *Ceram. Abs.*, **12** [2], 78 (1933). M.V.K.

**New mineralogy.** A. N. WINCHELL. *Amer. Mineralogist*, **18** [3], 81–90 (1933).—The aim of the scientific studies of minerals should no longer be merely the name of the mineral, but the determination of the precise composition in terms of end-members, and, for this purpose, accurate measures on optical constants are second in importance only to complete chemical analyses of carefully purified samples. G.R.S.

**Dispersion of soil-forming aggregates.** C. L. CLARK. *Soil Sci.*, **35** [4], 291–94 (1933).—Size distribution is dependent not only on the nature of the soil but also on the nature of the process used to determine it. G.R.S.

**Kaolin zone of Decize.** VICTOR CHARRIN. *Génie civil*, **101** [11], 287–88 (1932).—C. discusses the origin and deposits of kaolin and kaolin clay in Decize (Department of Nevre), France. M.V.K.

BOOKS AND BULLETIN

**Our Mineral Civilization.** THOMAS T. READ. Century of Progress Series. 165 pp. Williams and Wilkins Co., Baltimore, 1933. Reviewed in *Jour. Phys. Chem.*, **37** [3], 401 (1933).—The development and uses of the commercial minerals, important chemical elements, metals, and their alloys as applied by mankind are presented by R. in an interesting, clear, accurate, and concise manner. G.R.S.

**Borates.** ANON. H. M. Stationery Office, London, 1933. 2nd ed. 44 pp. Reviewed in *Pottery & Glass Rec.* [Eng.], **15** [1], 26 (1933).—The volume deals with the nature, uses, production, and trade in boric acid and borates and their occurrence and working. M.V.K.

**Geophysical Abstracts. No. 47.** F. W. LEE. Bur. Mines *Periodical Service Rept.*, GA 47. 26 pp. Price 10¢. The report reviews journal articles, books, and patents concerned with geophysical prospecting methods and equipment. For No. 46 see *Ceram. Abs.*, **12** [6], 242 (1933). R.A.H.

PATENT

**Method of concentrating beryllium oxide occurring in materials containing beryllium silicate or silicates.** LOUIS BURGESS. U. S. 1,905,340, April 25, 1933. The process of concentrating beryllium oxide occurring in materials containing beryllium silicate comprises admixing such a material with sufficient carbon to reduce to silicon at least a part of the silicon oxide in the material, subjecting the mixture to heat sufficient to cause the admixed carbon to reduce at least a part of the silicon oxide, thereby producing silicon and unreduced oxide, and separating the silicon from the oxide.

## Chemistry and Physics

**Preparation of thin sections of friable material.** T. H. HITE. *Bull. Amer. Ceram. Soc.*, **12** [5], 135–37 (1933).

**Thermochemistry and the periodic table.** T. C. SUTTON. *Nature*, **130** [3282], 474–75 (1932).—S. considers that, since the formation of chemical compounds depends on rearrangement among the electrons of the outer shells of the atoms concerned, it should be the aim of the thermochemists to connect changes of energy with the corresponding change in arrangement of these electrons. He calculates the energy of transfer of electrons on oxidation by dividing the energy of formation of the direct linking of oxygen to the element by the covalency of that element. The energy of formation values are taken from those obtained by Bailey from the band spectra (in the infra-red) of a number of nonpolar compounds.

| (1) Element | (2) Energy of linkage with oxygen per g. atom of element (k.-cal.) | (3) Covalency of element | (4) Column 2 / Column 3 | |
|---|---|---|---|---|
| First periodic series | | | | |
| Hydrogen | 110 | 1 | 110 | |
| Second periodic series | | | | |
| Carbon | 237 | 4 | 59.3 | |
| Nitrogen | 171 | 3 | 57.0 | |
| Oxygen | 118 | 2 | 59.0 | mean 58.6 |
| Fluorine | 59 | 1 | 59.0 | |
| Third periodic series | | | | |
| Silicon | 180(?) | 4 | 45.0(?) | |
| Phosphorus | 148 | 3 | 49.3 | |
| Sulfur | 101 | 2 | 50.5 | mean 49.9 |
| Chlorine | 50 | 1 | 50.0 | |

The energies of linkage with oxygen (column 2) are seen to be a periodic function of the atomic number, large for the early members and decreasing until a minimum is reached for the last member of the series. The covalency of the element (column 3) is a measure of the number of electrons transferred from the oxygen in order to produce a stable shell. The energy of linkage divided by the covalency (column 4) represents that portion of the energy of linkage which is directly associated with the transfer of one electron from the oxygen. Reference to the table shows that the energy of formation of the linkage of an element with oxygen (1) is proportional to the covalency of the atom of that element, (2) depends on the number of electron shells in that atom, and (3) is not affected directly by the nature of the nucleus. The energy of transfer of an electron on oxidation is approximately the same for all atoms with the same number of electron shells and is smaller the greater the number of such electron shells. J.L.G.

**Principles of material testing with gamma-rays.** R. BERTHOLD AND N. RIEHL. *Z. Ver. deut. Ing.*, **76** [4], 401–406 (1932); abstracted in *Metals & Alloys*, **4** [2], 35 (1933).—The possibilities of using the $\gamma$-radiation of radioactive elements for testing materials instead of X-rays are described. While the latter have a wave-length of $1 \times 10^{-7}$ to $5 \times 10^{-10}$, $\gamma$-rays have a wave-length of $5 \times 10^{-10}$ to $5 \times 10^{-11}$. The different sources of $\gamma$-radiation are described and, as a practical material, mesothorium can be used instead of the more expensive radium. The half-time value of Ra is 1700 years and that of mesothorium 26 years. The method of application of the preparations is explained. The tests resulted in the following conclusions: (1) X-rays are at present suitable only for the irradiation of great thicknesses (steel of more than 50 mm.); (2) the small radioactive preparations can easily and conveniently be placed even in fairly inaccessible parts; (3) practically no supervision is required during exposure; (4) the times of exposure are considerably longer for the testing of small or medium thickness (less than 100 mm.) than with X-rays of about 200 kv.; (5) defects are less clearly seen than with X-rays, and luminescent screens can not be used due to the low intensity of the radiation. As an example, with a mesothorium preparation of 30 mg. (value about 5000 M.) a steel of 150 mm. thickness could be photographed at 50 cm. distance from the plate in 40 hr. and a steel of 100 mm. thickness in 25 hr. E.P.R.

**Reactions on firing kaolins.** OTTO KRAUSE AND HEINRICH WÖHNER. *Ber. deut. keram. Ges.*, **13** [11], 485–520 (1932).—Five washed kaolins and one clay were examined by X-ray with respect to their behavior on firing with the aid of chemical and tensieudiometric disintegration tests with pholerite from Neurode. Conclusions were as follows: (1) The clay substance of these materials shows an interference pattern similar to that of the pholerite. (2) The kaolin dehydration products which develop from about 430° on do not have an individual crystal structure. This dehydration product forms a pseudomorph after pholerite, which yields no interference patterns with the X-ray and, on the basis of disintegration tests, is to be considered as a lattice of amorphous silica with movable deposited amorphous alumina which can be readily removed with hydrochloric acid or can be brought to crystallization by further heating. (3) The exothermic effect at 930° is truly produced by the formation of an aluminum silicate and is not to be claimed as a crystallization of alumina. Corundum can not be detected in the higher firing temperature ranges. It is proposed to call the resulting aluminum silica "Keramit" in order to distinguish the specific character of this artificial silicate which is not fixed in its chemical composition. (4) Neither the endothermic effect at 475° nor the exothermic effect at 930° forms sharp boundaries for the disappearance or appearance of new crystal phases. The extraction residues show that above this point the formerly

present crystal phases have been carried over or that new phases originate below this point. No explanation of the exothermic effect observed at 1200° could be obtained from the X-ray examination. E.J.V.

**Kaolin.** ROBERT SCHWARZ AND GEORG TRAGESER. *Chem. Erde*, **7**, 566–85 (1932).—The dehydration of kaolin was studied by a combined dilatometric and tensimetric method. The dehydration curves for natural and synthetic kaolins were similar. There is a considerable lag between the loss of $H_2O$ and the change in crystal structure. This is explained by assuming the course of dehydration to be kaolin ⟶ "anhydrokaolin," an unstable crystalline compound ⟶ amorphous metakaolin. The heat of dissociation of kaolin into metakaolin and $H_2O$ is calculated to be −33.5 kg. cal./mol. at 490°, and the heat of formation of kaolin from the elements is +18 kg. cal./mol. See also *Ceram. Abs.*, **10** [9], 662 (1931). (*C.A.*)

**Variation of the true and apparent electrical resistivities of quartz with temperature.** S. SHIMIZU. *Sci. Repts. Tôhoku Imp. Univ.*, **21** [3], 439–54 (1932).—The variation of the electrical resistivity with time and temperature has been studied with quartz plates cut perpendicular to the optical and electrical axes, respectively. In both cases the ratio of the apparent and true resistivities increases first and then decreases, as the temperature rises, and tends to unity. The first decrease of the ratio of the resistivities is due to a surface leakage of the charge accumulated between the electrode and the guard ring and the diminishing of the polarization potential as the temperature rises. The width between the electrode and the guard ring, *i.e.*, the leakage path, was found to be of great importance in obtaining exact values of conductivity of dielectrics, especially at a high temperature. W.M.C.

**Electrical conductivity of tridymite and cristobalite at their transformation temperatures.** S. SHIMIZU. *Sci. Repts. Tôhoku Imp. Univ.*, **21** [5], 882–905 (1932).—The electrical conductivities of quartz and its modifications have been studied. Quartz plates cut parallel and perpendicular to their optical axis were used for studying the transformation from $\beta$ quartz to tridymite at a temperature of 870°C. It was found that the conductivity changes abruptly with the plate cut parallel, whereas the plate cut perpendicular shows a continuous variation at the same temperature. The transformation of tridymite (low tridymite, low-high tridymite, and upper-high tridymite) was studied in the temperature range from 117 to 163°C. The specimen was taken from an open-hearth silica brick. The conductivity of tridymite varies anomalously at the transformation temperature. The transformation from low to high cristobalite was studied in the range from 200 to 275°C, using a specimen taken from the melted part of the same silica brick. The conductivity of cristobalite varies anomalously at the transformation temperature, as observed for the thermal expansion. The numerical values of the variations do not coincide exactly, the specimens containing some unknown fluxes. The variation of the electrical conductivity may be used in defining the transformation temperatures. W.M.C.

**Studies of dielectric constants. I. Variation of dielectric constant of quartz with the potential applied.** H. SAEGUSA AND K. NAKAMURA. *Sci. Repts. Tôhoku Imp. Univ.*, **21** [3], 411–38 (1932).—A high-frequency oscillating arrangement is used for precision measurements of the dielectric constants. The intensity of an audible beat produced by coupling two stable high-frequency circuits is magnified by a specially designed amplifier. The amplifier is coupled with an audio-frequency circuit. The electric capacity of the sample is measured by counting the final beats. The dielectric constant of a quartz plate cut perpendicular to its optical axis increases exponentially with the potential applied from about 2000 volts per 1 cm. thickness. No effect has been observed if the quartz plate is cut parallel to its optical axis (voltages ranging up to 12,000 volts per 1 cm. thickness). Experiments with increasing the temperature up to 410°C show no effect on a quartz plate cut parallel to its optical axis, whereas a plate cut perpendicular will show a considerable effect. W.M.C.

**Rotational analysis of ultra-violet bands of silicon monoxide.** PAUL G. SAPER. *Phys. Rev.*, **42**, 498–508 (1932). D.E.S.

**Measurement of the rate of adsorption at constant pressure.** P. V. MCKINNEY. *Jour. Phys. Chem.*, **37** [3], 381–87 (1933).—A method is suggested for the measurement of adsorption at constant pressure, previous work having been done at constant volume. G.R.S.

**Method for obtaining data for the sorption of vapors by solids.** J. L. PORTER. *Jour. Phys. Chem.*, **37** [3], 361–66 (1933).—A simple method for the rapid and moderately accurate study of sorption of liquids and vapors by solids is described. G.R.S.

**Velocity of solution of industrial aluminas in fused cryolite.** N. PARRAVANO AND

O. D'AGOSTINO. *Atti accad. Lincei*, **16**, 186–90 (1932).—The time required for the 3 types of $Al_2O_3$, Bayer, Haglund, and Blanc, to dissolve in fused cryolite at 1050° was measured. The first two consist essentially of crystalline $\alpha$-$Al_2O_3$, Haglund showing larger and more agglomerated crystals. Blanc $Al_2O_3$, made by decomposition of Al chloride or nitrate, is not crystalline although it is anisotropic and has a large specific surface area. The time of solution was measured by the change in conductivity of the fused solution of 15 g. of each $Al_2O_3$ in 100 g. cryolite. The change in resistance was measured by a bridge constructed as follows: The resistance consisted of a variable condenser, current was supplied by a thermionic valve oscillator, and a valve voltmeter with 2 stages of amplification and with a 3 v.-1000 ohm voltmeter as a milliammeter was used in place of the telephone. In this way, 0.001 ohm could be measured. The $Al_2O_3$ was added to the fused cryolite in a furnace held at 1050°, and the resistance of the solution measured (cryolite = 0.1682 ohm). The time required for the resistance to become constant was 4, 6, and 9 min. for Blanc (0.1757 ohm), Bayer (0.1772), and Haglund (0.1782) alumina, respectively, showing Blanc to be most readily soluble. The results prove that the conductivity of cryolite decreases with increasing concentration of $Al_2O_3$. By extrapolation, it was calculated that 100% $Al_2O_3$ solution has zero conductivity, *i.e.*, it is not dissociated in fused cryolite. (*C.A.*)

**Methods for the determination of the viscosity of slags.** K. A. POHLE. *Mitt. Forsch.-Inst. Ver. Stahlwerke A.-G. Dortmund*, **3**, 59–60 (1932).—The reactions between slag and metal are important in many metallurgical processes. As the velocity of a process often depends on the viscosity of the slag and the latter on the temperature, the various methods for the determination of coefficients were compared and certain rules developed for comparable measurements. A torsion method was developed which is useful and exact for laboratory purposes; a vessel containing the slag is rotated and the velocity with which an immersed rod is taken along is measured. 42 references. (*C.A.*)

**Binding energies in the growth of crystal nuclei from metallic atoms.** H. S. TAYLOR, H. EYRING, AND A. SHERMAN. *Jour. Chem. Phys.*, **1** [1], 68–76 (1933).—First order perturbation theory was employed to compute the binding energies of various geometrical configurations. G.R.S.

**Plasticity. I.** K. PFEFFERKORN. *Sprechsaal*, **65** [48], 855–58 (1932).—Plasticity is defined and its probable causes are discussed. The mechanism of the combination of water with the silicate molecule is explained on the basis of the atomic structure of these molecules. **II.** *Ibid.*, **65** [49], 873–75 (1932).—The effect of free $SiO_2$ and of hydrochloric acid on the plasticity is described. The free $SiO_2$ molecule is able to take up to four molecules of water, while the molecule of clay substance may take up to six. The water in the plastic clay body is chemically bound with coördinate valences, thus satisfying the unsaturated valence bonds present in these molecules. On the application of pressure, as in kneading, the water separates and the molecules can slide past each other. As soon as this pressure is removed the water again combines with the $SiO_2$ and the clay substance. W.W.B.

**Calculation of particle size and dispersoid analysis in ceramics.** HANS LEHMANN, R. STOPP, G. BARON, AND W. NEUMANN. *Sprechsaal*, **65** [36], 655–57; [37], 673–74; [38], 687–90 (1932).—A survey of the different methods of dispersoid analysis was made for the purpose of determining the best method for each particular case. (1) Particles over 60 microns in diameter are best determined by means of screens. This also serves to prepare the material for sedimentation methods of analysis. (2) For particles down to 20 microns in size elutriation analysis according to Schoene is employed. A correction depending on the nature of the material is necessary. (3) For rapid industrial control work a modification of Andreasen's pipette apparatus was found suitable between the limits of 60 microns and 5 microns. (4) For highly accurate research work the Lorenz modification of the Wiegner-Gessner apparatus is recommended. (5) For materials that must be worked dry Gonell's air separation apparatus is best. W.W.B.

**The system, ferrous oxide–ferrosoferric oxide.** R. VOGEL AND E. MARTIN. *Arch. Eisenhüttenwesen*, **6**, 109–11 (1933).—Thermal and microscopic investigations covered the range from 22 to 28% of oxygen. No uniform crystal was found containing as much oxygen as ferrous oxide. The substance which was believed to be ferrous oxide was found to be the mixed crystal "wüstite." The oxygen content of wüstite changes with the temperature. With a temperature increase of 575 to 1432°C, the oxygen content of wüstite increases from 23.1 to 24.7%. At 575°C, wüstite decomposes into oxyferrite and ferrous oxide as demonstrated by the fine-grained pearlite type structure found within the wüstite crystals. An alloy containing the same amount of oxygen as ferrous oxide is composed of a eutectic containing two saturated mixed crystals, one

γ-mixed crystal rich in iron, one mixed crystal of the wüstite type, and a few iron precipitates. W.M.C.

**X-ray study of the wüstite (FeO) solid solutions.** E. R. JETTE AND F. FOOTE. *Jour. Chem. Phys.*, **1** [1], 29–36 (1933).—A series of iron oxides with compositions between 76.08 and 76.72% Fe, all of them lying within the single phase solid solution area known as wüstite, were prepared, and the lattice constants and densities of the individual members were determined. The NaCl structure found by earlier investigators and considered by them to be the structure of FeO was found throughout this series. Contrary to earlier results the size of the unit cell decreases as the iron content decreases. The solid solution is of a complex type; an oxygen ion replaces an FeO group with an accompanying increase in valence of 2 $Fe^{++}$ to 2 $Fe^{+++}$. The results are discussed from the chemical and structural points of view. G.R.S.

**Determining $B_2O_3$ in glasses and enamels.** P. N. GRIGOR'EV. *Keram. i Steklo*, **9** [1], 21–22 (1933).—G. discusses the method of Wherry and Chapin (*Jour. Amer. Chem. Soc.*, **30** [11], 1687–1701 (1908)) for determining $B_2O_3$ in glasses and enamels. The method has been simplified and improved by G. by removing the injurious action of $Al_2O_3$, $Fe_2O_3$, ZnO, and PbO when present, and permitting the obtainment of satisfactory results for glasses and enamels containing from 3 to 11% $B_2O_3$. M.V.K.

**Chemical bond.** G. N. LEWIS. *Jour. Chem. Phys.*, **1** [1], 17–28 (1933).—Chemical bond is discussed under the headings, (1) structural framework, (2) pairs and bonds, (3) steric implications of the octet, (4) the molecule with completed electronic shells, and (5) molecules with incomplete shells. G.R.S.

**Method for determining the mass of electrolytic ions.** P. DEBYE. *Jour. Chem. Phys.*, **1** [1], 13–16 (1933). G.R.S.

**Extension of the phase rule for adsorption under equilibrium and nonequilibrium conditions.** IRVING LANGMUIR. *Jour. Chem. Phys.*, **1** [1], 3–12 (1933).—An adsorption field is defined as a homogeneous part of a solid or liquid surface on which adsorption can occur. In the presence of adsorbable components each field contains one or more surface phases. Adsorption experiments have demonstrated that in many cases all the intrinsic properties of an isolated surface phase are variables characterized by $C + 1$ degrees of freedom ($F$) where $C$ is the number of components. If this surface phase postulate (*S.P.P.*) applies to each surface phase in a system, then for a system in a state of complete equilibrium $F$ has the value $F_e = C + S - P_v - P_s + 2$ where $S$, $P_v$, and $P_s$ are the numbers of fields, volume phases, and surface phases, respectively. By considering the possible mechanisms, such as interphase mobility and vapor interchange by which equilibrium may be attained, this phase rule is extended to states of partial equilibrium, *e.g.*, cases where the surface phases and the volume phases are at different temperatures. The effects of electric fields are considered. Nonequilibrium states, divided into steady states and transient states, are characterized by values of $F$ greater than $F_e$. Experiments on transients by which $F$ can be determined may thus serve to determine $S$ when it is otherwise unknown. If the geometrical arrangement of the surface phases is known, such experiments serve to determine the surface diffusion coefficient, $D$, or the phase boundary resistance to diffusion. G.R.S.

**Separation of the alkalis in silicates and the titrometric determination of potassium.** P. N. GRIGOR'EV. *Sprechsaal*, **66** [10], 162–63 (1933).—The determination of the alkali content of silicates may be shortened and simplified. The silicate is first decomposed with HF and $H_2SO_4$. The excess of acids is removed by low temperature ignition. The $SO_3$ residue and the Mg are removed with $Ba(OH)_2$ solution. The excess $Ba(OH)_2$ and the remainder of the basic constituents of the silicate, except the alkalis, are removed with $(NH_4)_2CO_3$, $NH_4OH$, or $CO_2$. A modification of the cobaltinitrite method is used for the determination of potassium, and the sodium is determined by difference. W.W.B.

**Gravimetric determination of cobalt by dinitrosoresorcinol.** O. TOMICEK AND K. KOMAREK. *Z. anal. Chem.*, **91**, 90 (1932).—The method developed by W. R. Orndorff and M. L. Nichols has been carefully tested. Contrary to the statements by these authors, the cobalt precipitation is not a quantitative one, and the apparently satisfactory results obtained are due to compensating errors. The reaction product contains only 80% cobalt dinitrosoresorcinol, the remainder being dinitrosoresorcinol and adsorbed alkalis. Attempts to improve the method were unsuccessful. (*T.C.S.E.*)

BOOKS AND BULLETINS

**Chemico-Technical Investigating Methods. Vol. III.** (Chemisch-technische Untersuchungmethoden.) BERL AND LUNGE. Julius Springer, Berlin, 1932. 8th ed. 1380 pp. 184 illustrations. 98 Rm. Reviewed in *Chim. & ind.*, **29** [3], 548 (1933).—

This volume is devoted to the ceramic, glass, lime, and cement industries, mineral compounds, and the examination of explosives and pyrotechnical products. Three-quarters of the chapters devoted to ceramics and glass deal with physical and mechanical tests. The expositions are complete and well written. The study of porcelain alone occupies more than 100 pages devoted to the determination of density, porosity to liquids and gases, coefficient of dilatation, thermal and electrical properties, etc. The study of chemical methods shows the same care. M.V.K.

**Stereochemistry.** (Stereochemie.) KARL FREUDENBERG. Franz Deuticks, Leipzig and Vienna, 1932. 4 vols. Each volume 18.00 Rm. Reviewed in *Chim. & ind.*, **29** [3], 754–55 (1933).—F. presents in detail all the latest researches and theories dealing with problems related to structural properties of molecules, whether they are physical or chemical properties. M.V.K.

**Elements of Physics.** A. W. SMITH. 3rd ed. McGraw-Hill Book Co., New York, 1932. 778 pp. Price $3.50. Reviewed in *Mech. Eng.*, **54** [12], 884 (1932). F.G.H.

**Handbook of Chemistry and Physics.** Edited by C. D. Hodgman. Reviewed in *Mech. Eng.*, **55** [1], 68 (1933); see also *Ceram. Abs.*, **12** [5], 207 (1933). F.G.H.

**Theory of torsion balance with preliminary study of modification of instrument to decrease time of gravity measurements.** J. W. JOYCE. Bur. Mines *Tech. Paper*, No. 546. 46 pp. Price 5¢ from Supt. of Documents, Govt. Printing Office, Washington, D. C. The report presents a theoretical discussion of principles and properties of gravity field and interrelation of physical quantities involved to the torsion-balance equation and considers some practical features of the torsion balance. It also describes an investigation of the problem of reducing the free period of balance system. R.A.H.

## Book Review

**Organic Reagents for Metals.** ANON. 61 pp. Hopkin & Williams, Ltd., London, 1933. Price 1s 3d. The use of seventeen organic substances in the detection or estimation of metals is described. H.H.S.

## PATENTS

**Process of making base-exchange materials for water softening.** PERCY LASSELLE (Permutit Co.). U. S. 1,906,163, April 25, 1933. (1) The method of preparing base-exchange materials comprises mixing a solution of an alkali metal silicate with a solution of a nonalkaline compound of aluminum hydroxide and adding to the solution mixture a solution of an alkaline compound of aluminum hydroxide, the proportions and concentrations of the solutions being such as to form a jelly upon standing. (2) A method of increasing the porosity of precipitated base-exchange silicates comprises adding to the reacting mixture an acid and an alkali to provide soluble salts in excess of the amount resulting from the reaction which forms the base-exchange silicate.

**Recovering base-exchange material.** OTTO LIEBKNECHT (Permutit Co.). U. S. 1,906,166, April 25, 1933. In making base-exchange silicate gels, the process comprises incorporating in a wet gel gelatinized fine particles of a previously formed and dried gel and then drying and granulating the gel mixture.

**Compound silicate gels and method of making.** RAY RILEY (American Zeolite Corp.). U. S. 1,906,181, April 25, 1933. (1) A composition for water softening and other purposes is composed of an alkali alumino-silicate gel compounded from an alkaline artificial alumino-silicate gel and an artificial alumino-silicate gel nonalkaline at the time of compounding. (2) A process of making a base-exchange silicate gel comprises gelling a mixture of sodium silicate solution with an alkaline solution of a metal oxide, gelling another solution of sodium silicate with an acidic solution of a metal oxide, the final relative proportion of the acidic solution being sufficient to leave the gel mixture in a nonalkaline condition, washing the two gels with water pulping and intimately mixing the two washed gels, and drying and granulating the gel mixture.

**Process of making zeolites.** W. MCA. BRUCE (Permutit Co.). U. S. 1,906,202, April 25, 1933. In the manufacture of zeolites having an adjusted silica ratio, the process comprises adding the desired amount of silica in the form of a solution of silicate of soda to a solution of aluminum sulfate in such concentrations and in such proportions as to produce an ungelled solution mixture and thereafter adding a further amount of alumina to the mixture in the form of a solution of sodium aluminate, the molar ratio of silica to alumina and to soda in the zeolite product being adjusted between 13 and 1 $SiO_2$ to 1 each of $Al_2O_3$ and $Na_2O$ by inversely varying the relative proportion of the sodium aluminate to the aluminum sulfate put into the reagent mixture, the relative proportions of the three reagents being such as to leave the final mixed liquor slightly alkaline.

**Manufacture of water-softening zeolites.** W. McA. Bruce (Permutit Co.). U. S. 1,906,203, April 25, 1933. In making water-softening zeolite gels from aluminum sulfate, sodium silicate, and sodium aluminate solutions, the process comprises mixing sulfate and silicate solutions of concentrations exceeding 3° Baumé, separately mixing aluminate and silicate solutions of concentrations exceeding 5° Baumé, and then mixing these two mixtures of the solutions.

**Soda ash.** George Lynn (Pittsburgh Plate Glass Co.). U. S. 1,907,987, May 9, 1933. (1) The method of forming dense soda ash consists in treating a mixture of soda ash and water to bring it to a temperature above the transition temperature between $Na_2CO_3H_2O$ and anhydrous $Na_2CO_3$ while subjecting it to the increase of pressure above atmospheric pressure necessary at such temperatures and to a degree of concentration sufficient to cause deposition of solid material, thereby producing and depositing solid anhydrous $Na_2CO_3$ and separating the same from the mixture. (2) The method of forming dense soda ash consists in first forming a slurry of $Na_2CO_3H_2O$ crystals in saturated solution, raising the temperature of the slurry above the transition temperature between $Na_2CO_3H_2O$ and anhydrous $Na_2CO_3$ while subjecting it to the increase of pressure above atmospheric pressure necessary at such temperatures, thus causing transition of the monohydrate crystals into anhydrous $Na_2CO_3$ crystals, and separating the same from the mixture.

**Method of treating tricalcium phosphate.** H. E. White. U. S. 1,908,090, May 9, 1933. A method of treating tricalcium phosphate comprises the reduction of the phosphate in the presence of the sulfide of a heavy metal and coke, and then introducing easily fusible sulfides whereby the sulfide slag thus formed is sufficiently fluid to permit proper separation of the metals from the slag.

**Method of treating tricalcium phosphate.** H. E. White. U. S. 1,908,091, May 9, 1933. A method of treating tricalcium phosphate comprises charging a furnace with suitable quantities of tricalcium phosphate, a heavy metal sulfide, and coke, then applying sufficient heat to create the volatile vapors by maintaining a temperature in the furnace below the point of dissociation of the calcium sulfide but high enough to liberate the heavy metal from its sulfide, also maintaining in the furnace a slight vacuum, and then at suitable intervals tapping off from the furnace the heavy metal and the sulfide slag, whereby a sulfide slag is produced.

## General

**Strength and durability tests of mortar-mix mortar.** M. O. Spangler. *Jour. Amer. Ceram. Soc.*, **16** [5], 246–49 (1933).

**Removing iron compounds from clay.** Anon. *Brit. Clayworker*, **42** [492], 8 (1933).—Many clays would be greatly increased in value if some or all of the iron compounds present could be removed. One method consists in making the clay into a slip and passing an electric current through it. The iron compounds travel toward the opposite anode from the clay particles. A German patented method consists in grinding the dried clay and treating the powdered material with sulfuretted hydrogen gas, the resulting iron sulfides being removed by solution in dilute sulfuric acid. A method patented in France consists in suspending the clay in a weak solution of soda, then adding sulfurous acid in the presence of a reducing metal such as zinc or aluminum, and separating the soluble iron compounds by filtration. According to a Swiss patent, if about 4% of ferrous sulfate is added to the clay it acts as a catalyst and permits dilute sulfuric acid to remove a large proportion of the other iron compounds present. In two other French patents the clayware is heated in the presence of chlorine gas at 600 to 700°C. This treatment effects a combination between the chlorine and some of the iron compounds, and as the resultant substance is volatile, it escapes via the chimney. An American patent calls for mixing aluminum chloride with the clay, and subsequent heating of the ware causes evolution of the chlorine and iron as ferric chloride. R.A.H.

**Slag-tap furnaces.** A. L. Baker. *Fuels & Steam Power*, Vol. 54, No. 1 (1932); abstracted in *Mech. Eng.*, **54** [4], 297–98 (1932).—The molten slag-tap furnace is described from its original application to a power-plant boiler to the present. Troubles in operating large furnaces with this type of ash removal are discussed with the remedies applied. Experimental data are given. F.G.H.

**Method for determining fuel burning rates in heating boilers fired by automatic devices.** R. C. Cross. *Heating & Ventilating*, **29** [1], 41–42 (1932); abstracted in *Mech. Eng.*, **54** [4], 311 (1932). F.G.H.

**Pulverized-coal firing in fire-tube boiler.** O. Leppin. *Arch. Wärmewirt.*, **13** [10],

263–65 (1932); abstracted in *Mech. Eng.*, **55** [1], 69 (1933).—The advantages of fire-tube boilers over water-tube boilers are described. Results of tests with different types of furnaces are discussed. F.G.H.

**Determination of carbonate, hydroxide, and phosphate in boiler waters.** W. C. SCHROEDER AND C. H. FELLOWS. *Trans. Amer. Soc. Mech. Eng.*, Vol. 54, RP-13 (1932); abstracted in *Mech. Eng.*, **55** [1], 58 (1933). F.G.H.

**Combination waste-heat and pulverized-fuel boiler unit.** W. H. D. CLARK. *Combustion*, **4** [3], 20–26 (1932); abstracted in *Mech. Eng.*, **54** [12], 867–68 (1932). F.G.H.

**Tank car for handling dry bulk commodities.** GENERAL AMERICAN TANK CAR CORP. *Railway Mech. Eng.*, **106** [9], 360–61 (1932); abstracted in *Mech. Eng.*, **54** [11], 812 (1932).—The recently developed "Dry-Flo" tank car, designed to handle such dry bulk materials as cement, lime, silica sands, soda ash, clays, earths, etc., is described. Illustrated. F.G.H.

**Scientific work of the Government of the United States.** R. D. CHAPIN, G. K. BURGESS, AND R. S. PATTON. *Sci. Monthly*, **36**, 193–224 (1933).—The work of the Bureau of Standards and the Bureau of Mines and other activities are described. H.H.S.

**Power and thermal technique in 1932.** NEUMANN. *Brennstoff-Wärmewirt.*, **15** [1], 1–19 (1933); abstracted in *Feuerfest*, **9** [3], 45 (1933).—A short description of innovations made in industrial furnaces is given. M.V.K.

**Profits earned with the aid of instruments.** ANON. *Clay-Worker*, **99** [4], 138–39, 147–48 (1933).—Brick and clay plants that are earning profits today have readjusted costly operating conditions through better control of kilns, driers, etc. These companies have modernized their production methods by the installation of indicating, recording, and controlling instruments to aid them in speeding up firing, saving fuel, improving quality, and increasing operating efficiency. Reports from different companies are given. Illustrated. E.J.V.

**Standardization.** W. A. IRVINE. *Clay Prod. News*, **6** [3], 6–7 (1933).—Standard methods of testing raw materials, processes, and finish to ensure required results in the finished products are discussed. W.W.M.

**The silicosis racket.** EDITORIAL. *Bull. Amer. Ceram. Soc.*, **12** [5], 127–29 (1933).

**Silicosis suit appeal of the Pennsylvania Pulverizing Co. in the United States Circuit Court of Appeals for the Third Circuit No. 4861; Term 1932.** EDITORIAL. *Bull. Amer. Ceram. Soc.*, **12** [5], 129–34 (1933).

**Good housekeeping at Falks.** V. J. HYDAR. *Foundry*, **61** [2], 10 (1933).—Methods of dust control used in this modern steel foundry for the elimination of silicosis are described in detail. Illustrated. F.G.H.

**Dust elimination in the pottery industry.** EDWARD SCHRAMM. *Jour. Amer. Ceram. Soc.*, **16** [5], 205–13 (1933).

**Venting dust explosions.** H. R. BROWN AND R. L. HANSON. *Chem. Met. Eng.*, **40** [3], 116–19 (1933).—The experimental structure consisted of a room, a gallery, and a tower. The fixed glass windows in the structure provided a factor of safety by breaking when the venting area was not sufficient to prevent the development of excessive pressures. Diagrams show the breaking strength of scored glass. G.R.S.

**Liquid oxygen explosives.** T. COULTER AND A. E. LANCE. *Jour. Chem., Met., Mining Soc. S. Africa*, **33** [5], 142–60 (1932).—This paper describes the methods and features of safety and economy in the use of liquid oxygen explosives in mines and quarries. W.E.R.

**Shooting methods for the quarry.** ANON. *Tonind.-Ztg.*, **57** [24], 289–90; [26] 311–12 (1933).—This is a review of a paper by Lämert in Nobel-Hefte, published by the Dynamit-Akt.-Ges. Troisdorf (Cologne). Different methods of preparing the shooting, installing the powder, etc., are outlined in detail. Illustrated. W.M.C.

**Buy American and give Americans work.** EDITORIAL. *Bull. Amer. Ceram. Soc.*, **12** [5], 121–27 (1933).

**Prosperity of ceramic industry depends on adequate tariff protection.** ANON. *Ceram. Ind.*, **20** [4], 183–85 (1933).—The possible action of the present administration with respect to tariffs is discussed with especial reference to the ceramic industry. Facts and figures are cited on present conditions. It is pointed out that with the depreciated foreign currencies, the present tariff is of no value. Industry should unite against lowering the rates. W.W.M.

**Management essentials for recovery.** C. M. BIGELOW. *Mech. Eng.*, **54** [11], 749–52 (1932).—B. outlines the industrial management procedure required to bring about a general recovery of sound business conditions as follows: (1) Determine product

characteristics from the consumer's viewpoint; (2) determine the minimum volume that can be absorbed by economic distribution efforts; (3) organize the production facilities to produce this volume; (4) consider this minimum volume as normal and meet increased demands by overtime or additional regular hours of labor; (5) measure all efforts of personnel and compensate them in terms of their contribution to the ultimate profitableness of the industry; (6) put aside, for all time, the "volume complex"; (7) consider maintenance of employment, building up strong cash reserves, and adequate research just as essential as insurance; (8) develop a spirit of coöperation within each industry rather than competition. F.G.H.

**Production management applied to the drafting department.** W. J. KUNZ. *Management*, Vol. 54, No. 1 (1932); abstracted in *Mech. Eng.*, **54** [8], 585 (1932). F.G.H.

**Keeping the research staff posted on current literature.** P. K. FROLICH AND D. F. BROWN. *Research Lab. Rec.*, **11** [5], 112 (1933).—Few contributions made by technical research organizations are truly original. A distinction between patents granted within a group frequently is vague and hard to recognize even for one skilled in the art. Each industry is built on a few basic discoveries. Only once in a great while do research workers produce something basically different which may form the nucleus of a new structure. The overwhelming number of contributions is the result of collective thinking. Critical analysis of original ideas invariably shows that their conceptions are inspired by surroundings. Creative thinking can not thrive in technical isolation. Ideas occur because the time is ripe for them to take form, and experience shows that not only one competitive organization but several produce the same idea simultaneously. For example, a company became engaged in a new and exceedingly promising project and patent applications were filed with the utmost expediency, but interference was declared by no less than seven competitive companies who had filed applications along similar lines at about the same time. There was no especial need for this particular process to solve an urgent problem within that industry. The new method of attack resulted from several isolated clues contributed by current literature. The library of the Standard Oil Development Co. and its informational service are described.

**Control of research expense.** W. A. HAMOR AND G. D. BEAL. *Ind. Eng. Chem.*, **24** [4], 427–31 (1932); abstracted in *Mech. Eng.*, **54** [6], 454 (1932).—The budgeting of research expense and procedures of research control in industrial management are discussed. F.G.H.

**Coördination of research and engineering with production and sales.** C. L. BAUSCH. *Management*, Vol. 54, No. 4*a* (1932); abstracted in *Mech. Eng.*, **54** [11], 799 (1932).—An exposition is given of the organization of the Bausch & Lomb Optical Co., Rochester, N. Y., insofar as it affects the function of research and engineering. F.G.H.

**Selection and training of industrial research personnel.** W. N. JONES. *Ind. Eng. Chem.*, **24** [4], 423–27 (1932); abstracted in *Mech. Eng.*, **54** [6], 454 (1932).—Factors involved in the selection of research workers are discussed. F.G.H.

**Technical curricula and liberal education.** R. P. BAKER. *Mech. Eng.*, **55** [1], 23–26 (1933).—The degree of liberalization desirable in a technical education is considered. F.G.H.

**Causes of turnover of technical men.** H. L. HORNING. *Jour. Soc. Automotive Eng.*, **30** [2], 98–100 (1932); abstracted in *Mech. Eng.*, **54** [5], 381 (1932).—Factors affecting the continuation of employment of technical men and causes of dissatisfaction among them are discussed. F.G.H.

**Engineer in public life.** D. S. KIMBALL. *Mech. Eng.*, **55** [1], 7–9 (1933).—The broad technique which an engineer of any type must acquire and the wide range of subjects with which he must be familiar, if he is to be an important figure in the industrial world of today, are described. F.G.H.

**Economic characteristics of the manufacturing industries.** W. RAUTENSTRAUCH. *Mech. Eng.*, **54** [11], 759–70 (1932).—An analysis is given of the costs of production, management, and merchandizing of products at varying rates of output, upon the basis of which a graphic portrayal of their relationships to plant capacity utilized is set up. F.G.H.

**Variations in maintenance costs and procedure.** E. V. STOODY AND G. I. ROSS. *Management*, Vol. 54, No. 3 (1932); abstracted in *Mech. Eng.*, **54** [8], 586 (1932). F.G.H.

**Nonproductive workers share in Norton Co. wage plan.** J. GESCHELIN. *Automotive Ind.*, **66** [6], 190–93 (1932); abstracted in *Mech. Eng.*, **54** [5], 384 (1932).—The plant layout has been rearranged and new equipment added in order to make wage incentives effective in the Worcester plant of the Norton Co. Formulas for earnings curves are

given and results of the new wage plan are compared on the basis of productive hours. F.G.H.

**Brick, tile, and pottery production in New Zealand.** J. W. BUTCHER. *N. Z. Official Yearbook*, **41**, 410 (1933).—In 1931, 61 works employed 946 persons. Wages paid were £213,895. Brick manufactured amounted to 37.6 million, of the value of £221,177. The total value of ceramic manufactures was £564,489. H.H.S.

**One-week school for brickmakers at Zwickau, Germany.** ANON. *Tonind.-Ztg.*, **57** [24], 291–92 (1933).—The following papers were read and discussed: (1) "Faults encountered in manufacturing roofing tile by means of the extruding machine," by Kaufmann; (2) "Materials and chemistry in the manufacture of hard-fired brick," by Avenhaus; (3) "Tertiary and diluvial clay deposits," by Fischer; (4) "Manufacturing structural clay products," by Kern; (5) "Moist air driers," by Beyer; (6) "Faults in water-smoking and firing ring and zigzag kilns," by Beyer; (7) "Diesel engines for automobiles and power plants," by Riepe; (8) "Coöperating in selling or in manufacturing," by Baudisch; (9) "Origin and composition of fossil fuel," by Fischer; (10) "Additions to raw materials," by Avenhaus; (11) "Water supply in brick plants," by Avenhaus; (12) "Chemistry in brick plants," by Kaufmann; and (13) "Manufacture of standardized drain pipe," by Kaufmann. A number of plants was visited. W.M.C.

**Meeting of the German Manufacturers of Sand-Lime Brick.** ANON. *Tonind.-Ztg.*, **57** [29], 344–46 (1933). W.M.C.

**Leipzig Spring Fair, 1933. Building fair and building meeting.** ANON. *Tonind.-Ztg.*, **57** [26], 307–309 (1933).—The main subjects discussed at the meeting for building materials were costs of brick, construction of silos, and the new Government commission for masonry. W.M.C.

### BOOKS AND BULLETIN

**Development of American Industries.** Edited by J. G. Glover and W. B. Cornell. Price $5.00. *Foundry*, **61** [2], 61 (1933); for abstract see *Ceram. Abs.*, **12** [6], 247 (1933). F.G.H.

**Unit Processes and Principles of Chemical Engineering.** J. C. OLSEN. 558 pp. D. Van Nostrand Co., Inc., New York. Reviewed in *Chem. Met. Eng.*, **40** [3], 147 (1933). G.R.S.

**Marvels of Modern Chemistry.** B. L. CLARKE. 347 pp. Harper and Brothers, New York. Reviewed in *Chem. Met. Eng.*, **40** [3], 147–48 (1933). G.R.S.

**Industrial Management in This Machine Age.** F. A. WESTBROOK. Price $3.50. Reviewed in *Mech. Eng.*, **55** [1], 68 (1933); for abstract see *Ceram. Abs.*, **12** [4], 176 (1933). F.G.H.

**Places of occurrence of injury from falls of roof.** J. W. PAUL AND D. L. SIBRAY. Bur. Mines *Rept. of Invest.*, No. 3203. 13 pp. Free. The report shows from a review of data covering eighty mines that the greatest percentage of accidents from roof falls occurs at the working face. It enumerates practices which, if followed, would materially reduce such accidents. R.A.H.

### PATENTS

**Method for treatment of ceramic materials and articles formed therefrom.** MARSHALL LASLEY. U. S. 1,906,384, May 2, 1933. The method of treating inherently plastic clay or shale containing impurities comprises the steps of reducing it to a fine state of subdivision, approximately 8-mesh and finer, and subjecting it to heat in intimate contact with an oxidizing atmosphere.

**Process for preparing clays.** J. F. WAIT. U. S. 1,907,690, May 9, 1933. The process of refining clay comprises adding a liquid, producing a fluid mixture with an excess of 65% of liquid, permitting the mixture to form a plurality of layers of different densities, separating a fraction of an apparent density different from the uppermost layer and from the lowermost layer, and removing liquid from the so separated fraction.

**Rock wool and composition for producing.** E. R. POWELL (Banner Rock Corp.). U. S. 1,907,868, May 9, 1933. An oxidized rock wool comprises silica and basic materials in the ratio of $1^1/_2$ to 2 parts by weight of silica to 1 part by weight of basic materials.